# Why Not Honor Them More Often?

**We appeal to our readers for an answer to this question.**

IT SEEMS that during recent years scientists and inventors have at last begun to receive some recognition. Moving pictures have dramatized the life and accomplishments of Louis Pasteur, Alfred Nobel, Alexander Graham Bell. But in each of these, the honor has been bestowed after death and hence can be of little satisfaction to those whose careers have been glorified.

When all is said and done, the world owes all of its material progress to scientists and inventors. Every great industry owes its existence to such men. Without their accomplishments the world would still be in the Dark Ages. This has been said over and over again but nobody has ever done anything about it.

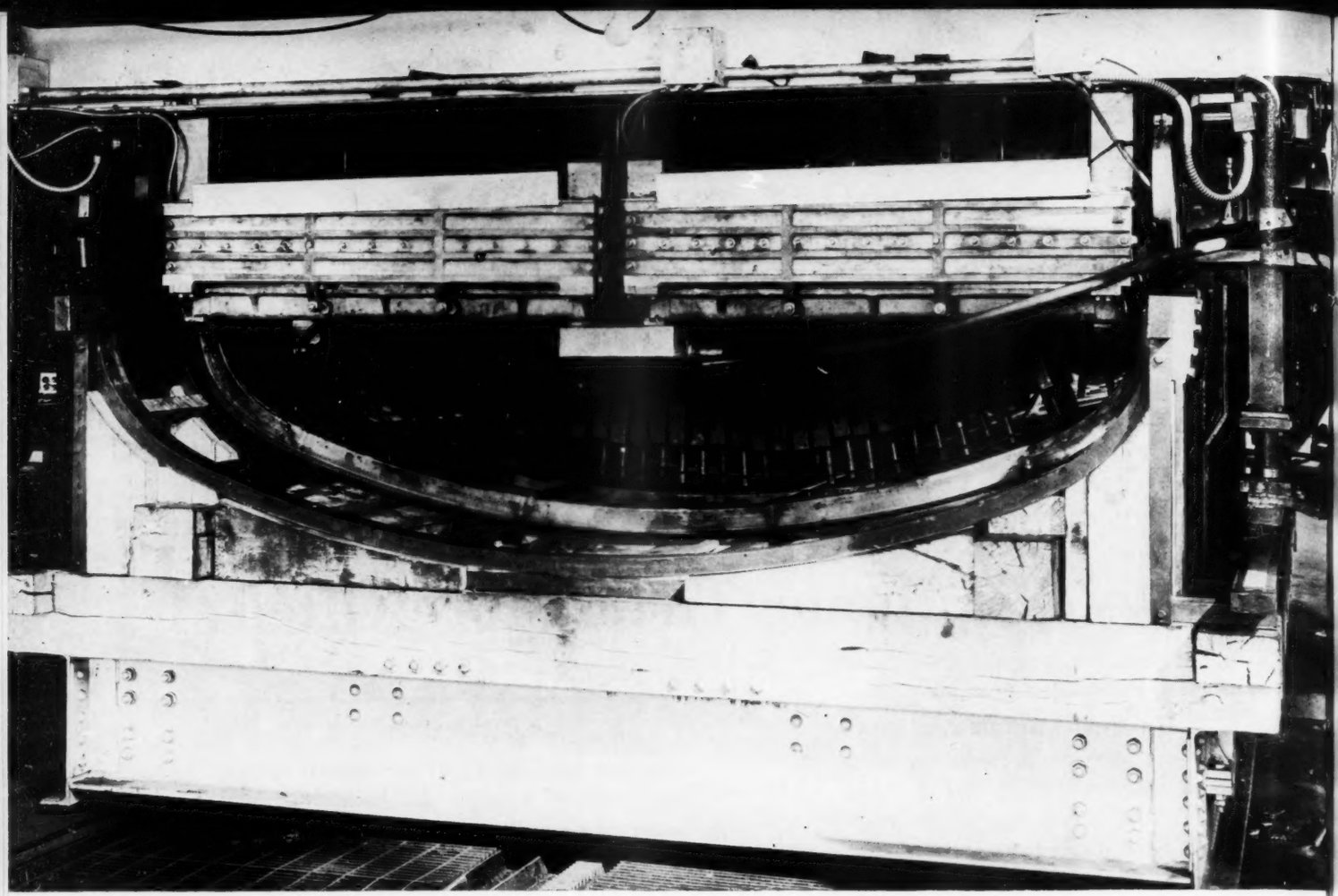
However, last July prominent men among the members of the National Association of Manufacturers decided that there ought to be a celebration of the 150th anniversary of the founding of the American Patent System. Some wise head or heads suggested that it would be specially fitting to celebrate the event by honoring the men who by their patent-protected inventions made possible American industry and the American way of living. Thus was launched the Modern Pioneers' movement.

Upon invitation, American manufacturers nominated more than 1,000 men to receive awards. A committee of six scientists headed by Dr. Karl T. Compton president of M.I.T., selected the 500 who were awarded scrolls at 15 regional dinners. And at the national dinner, the 19 selected as the most outstanding ones of the 500 Modern Pioneers were awarded silver placques.

We are unstinted in our praise to the men who launched this idea and to the National Association of Manufacturers for sponsoring it. No more fitting way to celebrate the 150th anniversary of the United States Patent System could be imagined. But must we wait for another Patent System celebration before honors are again bestowed upon inventors? Why not have such a celebration at stated intervals of about five years? And instead of honoring 500 inventors, the accumulation of 25 years of inventing, there would be only 20 or 25 to honor. This would have the desirable effect of concentrating attention on fewer men, thus giving them more individual publicity and thereby increasing the value of the award. It would be a distinction that would appeal to many and would elevate science and engineering.

In making this suggestion PRODUCT ENGINEERING offers to support it and promote it if it meets with favor. If the engineering designers and inventors think well of it, we would like to hear from them to the end that we might be able to judge the value of this suggestion.

G. F. Nordenholt.



*Specially designed automatic machine with frame and sheet clamped in position on jig car and ready for spot welding. Horizontal or vertical rows of spots can be made at the rate of 60 per minute. To obtain economy in fabrication time and materials handling two jig cars are used, while one car is being unloaded and then reloaded, work on the other car is being welded*

# DESIGNED FOR WELDING

V. R. WILLOUGHBY
*Vice President in Charge of Engineering, American Car and Foundry Company*

**How BALANCED DESIGN, using to best advantage the materials and production processes available, solved the problem of how to build lighter and stronger railroad cars that compete successfully with other forms of transportation.**

WHEN AUTOMOBILES, trucks, buses and airplanes became major factors in transportation, the railroads found themselves faced with a situation that demanded radical changes in the design of their equipment. The obvious answer to the problem of winning passengers was to offer safer, more comfortable, de luxe and faster service. To profitably compete against other forms of freight transportation required larger, lighter freight cars of superior design with reference to factors such as initial cost, cost of hauling and handling freight, and in addition lower maintenance cost.

A great variety of problems were encountered in the design of ultra modern railroad passenger cars. In order to win customers, cars were quickly equipped with air conditioning and heat insulated. Truck designs and body mountings to give smoother silent riding were developed. Then rapidly followed "streamlining" and de luxe appointments. When it is considered that all these improvements had to be accomplished without increasing the weight of the equipment and without diminishing the safety of the cars in service, it becomes evident that new ideas in design and construction had to be created. A more efficient type of structural design that also made possible more economical production methods had to be developed. Naturally, thoughts were directed towards investigating the possibilities and advantages presented by welded design.

The use of welding in railroad car building is not new. As long ago as 1908 the American Car & Foundry Company built a gas welded tank car. Again, in 1911, the same company designed and built a gondola car wherein the sheets were spot welded to the frames. This last car was still in service with the welds still in good condition, in 1925. During the period from 1911 to 1923, the further development of welded cars lagged, largely on account of the war, but from

then on progress became faster. Welding became used more and more extensively for car parts, as welding the joints in deck sills and plates, door sills and headers and similar parts. Spot welded passenger car doors, both steel and aluminum, have been designed and built by the American Car and Foundry Company since the middle of the twenties. With this background of experience, we undertook the task of analyzing the possible advantages in the design of railroad cars of welded construction substantially throughout the car. The first step was to investigate the inherent characteristics of riveted construction and the possible advantages of welding.

In any riveted construction the loss of metal, and hence the loss of strength, on account of rivet holes is a serious handicap that cannot be avoided. It is not only a matter of the loss of section area, but the holes also cause stress concentration. In addition, the rivets will creep when under high stress. Joints subjected to stress concentration and creep become weakened and in time will fail under a load lower than the original static strength of the joint.

Another serious objection to riveted joints is that the cross-section of the connected members at the joint must be increased to give the joint the strength required. Usually the thickness or cross-sectional area of the rolled structural member or sheet used must be increased. After calculating the thickness to give the desired working stress, it must be divided by the efficiency of the riveted joint. Thus almost 50 per cent must be added to the thickness of the sheets in car tanks because the efficiency of the double-rivet lap joint used is only 70 per cent.

In addition to the inherent handicap of the riveted joints with reference to strength, it must also be considered that in many riveted constructions metal must be added solely to provide space for rivet heads. When the conventional standard rolled sections were first developed, flanges were designed mainly to provide space for riveting; the distribution of the metal over the stressed cross-section to procure the best strength and stiffness was usually a subordinated consideration or a compromise.

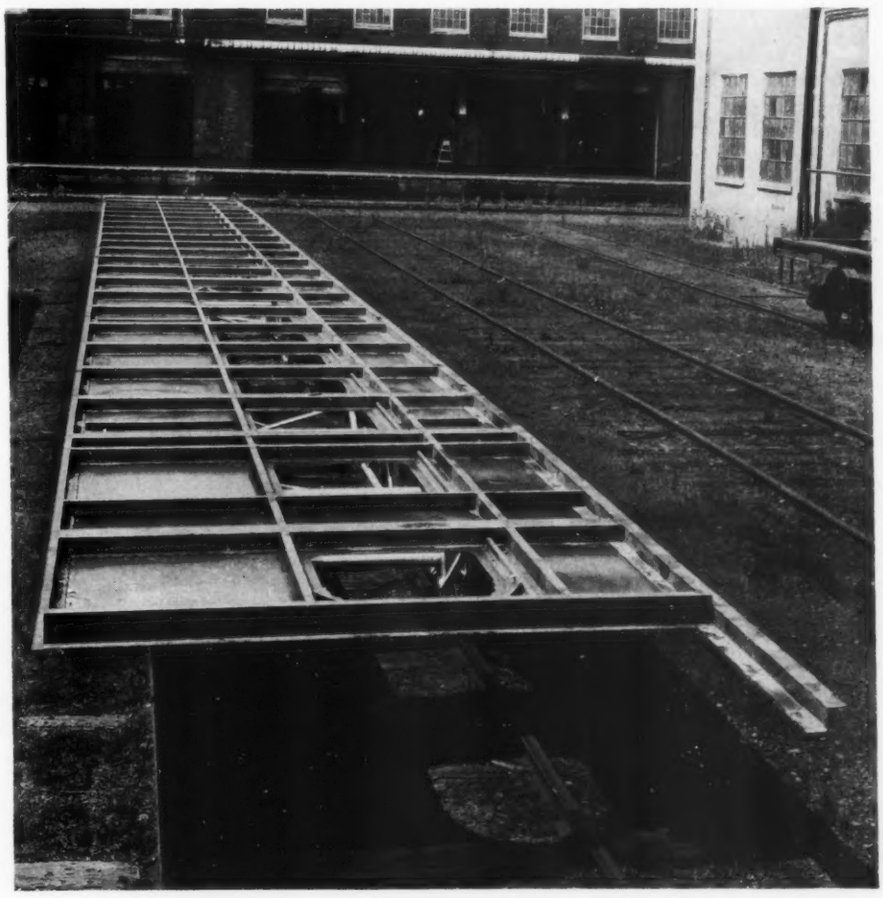
Finally, it is often impossible to use the thin sheets otherwise permissible if the sheets must be fastened by riveting. With thin sheets subjected to stress and fastened by riveting, the metal around the rivet hole is liable to be crushed by the high stresses imposed on the relatively small area in the wall of the rivet hole; that is, the bearing value of the sheet or plate limits the strength of the riveted joint.

Welding was the obvious answer to the question as to the type of construction to be adopted in many details in the design of improved railroad equipment. Welding permits the best distribution of the metal, thus eliminating superfluous material, and gives to the joint the full strength of the member.

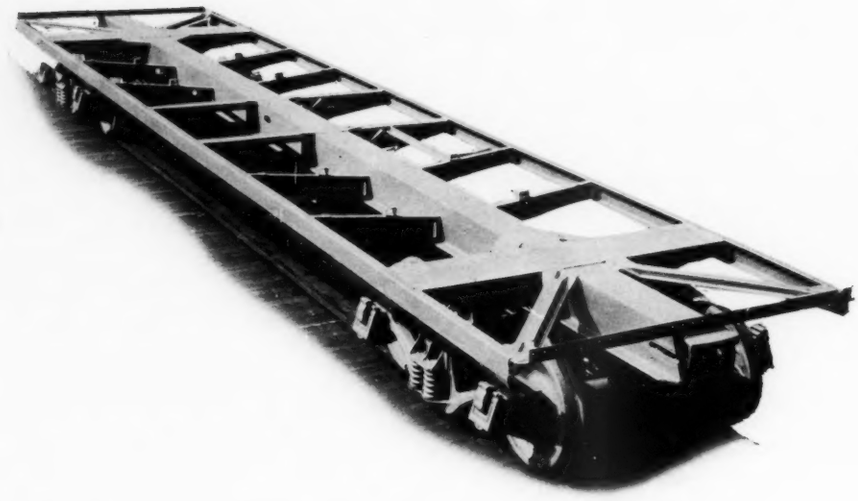
By taking advantage of all of the possibilities inherently available in welded construction it is possible to develop a design of car that will be structurally lighter and more than compensate for the weight added by air conditioning equipment and luxurious appointments. At the same time the new design must have all of the safety of the previous conventional designs. The success of the design development program based on this philosophy is evidenced by the new cars now in service. They are lighter and stronger than the older ones of conventional design and riveted construction, in spite of the added weight of air conditioning equipment, luxurious appointments and increased length.

One of the major steps leading toward the "all-welded" railroad car as we know it today was the designing in 1934 of the spot-welded passenger cars with completely riveted underframes, for the "Rebel" trains running on the Gulf Mobile and Northern Railroad between New Orleans and Jackson, Tennessee. It has long been recognized that a perfectly smooth car exterior cuts down wind resistance, gives a better appearance and is easier to clean. Such an exterior surface in cars can be obtained in a practical manner only by spot welding which also has the advantages of making stronger joints without the weakening effect of rivet holes. The side sheets and roof sheet of the cars for the "Rebel" trains were spot-welded to the framing. Two trains of these cars were delivered in 1935 and a third train in 1937 and all have had excellent service records.

The next step was a study of possible design changes that would enable improvements in production methods in order to reduce costs. The "Rebel" cars had sides and roof made of relatively small spot-welded panel sections, the size of the panels being limited by the fact that larger panels could not be handled at the stationary spot welder. Thus, many panel units per car were required. The conclusion from this part of our study was that, if feasible, we would, in cooperation with welding machinery manufacturers, develop a spot-welding machine that could spot weld a complete side and a complete roof and would be capable of making many spot welds



*Finished side frame unit with sheet spot welded to frame. Spots show only on the framing, electrode on jig car being a copper sheet. Hence there are no dimples visible on the finished car*



*Completely arc-welded freight car underframe ready to receive the ends, sides and roof. The rivet holes for fastening the end sheet can be seen clearly*

simultaneously. Such equipment was developed and is now in three of the plants of the American Car & Foundry Company. These special spot welders have 62 electrodes capable of making that many spot welds individually and consecutively, each requiring less than a second of time. They are capable of spot welding vertical or horizontal rows. The welding is done with the work in a horizontal position clamped to a welding jig mounted on wheels and running on tracks underneath the welder platen. The top of the welding-jig car is a copper plate on top of which is laid the sheet. Over the sheet is placed the framing which is clamped in position. Thus the movable top electrodes bear against the thicker framing members and the "spots" are out of sight in the finished product. Operation of this multiple spot welding machine is entirely by push-button control.

A second important conclusion revealed by the study of shop operations was that the amount of arc welding done on the final assembly track should be reduced to a minimum. Only a relatively few men can arc weld on a car at the same time on account of the danger of injury to the eyes from the ultra violet light. It is practically impossible for other trades to work on a car while the arc welding is going on. Also, to continue with welding on the final assembly on the track would be a non-economic method requiring many hand welders and many track positions. Obviously, it would be best to eliminate all arc-welding from the final assembly track.

Summarizing, the conclusions from the studies were: develop a design of car wherein the framing of the underframe, the framing of the two sides and roof would each be assembled by arc-welding in a jig; the side sheets and roof sheets would each be fastened to their respective framing by the special multiple spot welder mentioned above; the finished welded sub-assemblies consisting of underframe, sides and roof would then be riveted together subsequently on the final assembly track.

This is the construction finally adopted. The rivets securing the sides to the underframe and the roof to the sides are vertical rivets spaced approximately 3½ in. All of the rivets are entirely inside the car, thus giving a construction that has a smooth exterior surface that lends itself to streamlining and also cuts down the resistance caused by head and yaw winds.

As an example of the weight saved by welded design, a comparison of riveted versus welded center sill will be given. A similar comparison of other units of a car gives comparable results. The center sill is the backbone of the railway car structure. It acts as a carrying member in distributing certain local loads to the transverse members of the underframe, which in turn transmit some to the load carrying side structure. Its principal function is that of a column to take care of the horizontal shocks and impact incident to train operation imposed on it by the car coupler. A portion of a conventional riveted center sill for passenger cars is shown in the accompanying illustration. The great number of rivets required, the abrupt discontinuities of cross-section, the wasted metal in the flanges and similar undesirable features of riveted construction are evident.

Several progressively improved designs of welded center sills were considered in the course of developing the final design shown here. The rolling of a single structural member of special cross-section for use as a center sill was out of the question. The next best thing was to develop a special section of such design so that two members of this special section, when placed together, would give the desired center sill section. The result is the basis of the welded design shown here.

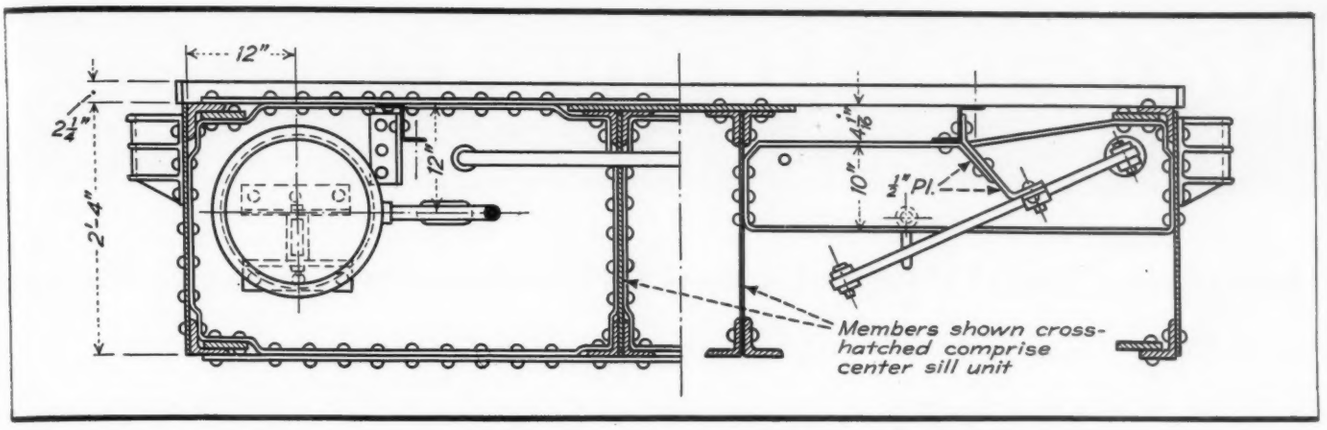
In the final design of center sill as shown in the accompanying illustration, two pieces of a special Zee section, each the full length of the center sill, are placed with the top flanges of the Zee in abutment. The two members are then arc welded together. Thus is obtained the unit section desired.

Box cars with such welded center sills were submitted to exhaustive tests along with the best types of box cars that had been built previously. In the older cars, the riveted center sill had a cross-sectional area of 28 sq. in., whereas in the new cars the cross-sectional area of the welded center sill is only 21.3 sq. in. The cars with the new welded center sill of the design shown here had a shock-resisting strength 20 per cent greater than that of the older cars with riveted center sill. Thus, 20 per cent greater strength was obtained with a center sill construction, wherein the cross-sectional area is approximately only 75 per cent of that of the old conventional riveted sill. The net result is a center sill construction that is 20 per cent stronger and weighs about 23 lb. per running foot less than the comparable center sill of the old conventional riveted design.

With reference to the cost of the welded center sill construction as compared to the riveted construction, the cost of the smaller amount of steel required is only one item. There is also a substantial saving in the labor cost of fabricating. As can be seen in the illustration, the welded center sill eliminates the coping of flanges and to a large degree the punching of holes necessary with the old design.

A similar detailed comparison of riveted versus welded bolsters, cross bearers, and cross ties would show similar savings in weight and costs, hand in hand with greater strength and rigidity. These underframe cross-members are assembled as far as possible as individual units and welded in jigs in order to assure uniformity of positioning and dimensions. The individual units are then assembled in a jig together with the longitudinal sill structure, and arc welded. Thus is assured the correct location and proper alignment of the finished underframe structure. The side frames of the car and the roof framing are jig welded in a similar manner.

On the track, the final assembly may be either by welding or by riveting, but as explained above, from a production angle, riveting is preferred. Riveting also has an advantage when maintenance is considered. With the side frame riveted to the underframe and the roof riveted to the top of the side frame, it is a simple matter to replace any one of the four units as it would merely be necessary to cut out the rivets, replace the damaged




*Cross-section of a typical riveted passenger car underframe. Extra metal is required to compensate for the many rivet holes*

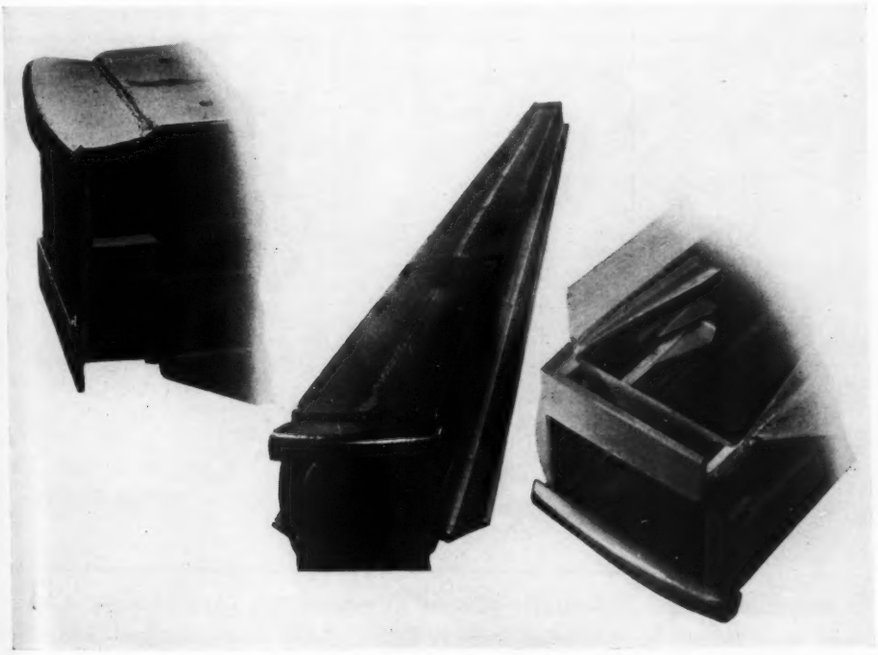
section with a new section, and then rivet. Local damage to the car structure is readily repaired by welding. The damaged piece or part may be cut out and replaced by fusion welding.

An equally important factor is the kind of material used. With arc welded construction, it is of course highly important that the material selected be one which welds readily. This requirement, plus strength consideration, naturally led to the selection of a low alloy steel with high tensile strength in the as-rolled condition, of which there are many brands available. These low alloy high tensile steels have a yield strength ranging from 50,000 to 60,000 lb. per sq. in. as compared to a yield strength of 32,000 lb. per sq. in. for low carbon open hearth steel. The modulus of elasticity of both the low carbon open hearth and the high-tensile steel is practically the same, namely, 29,000,000 approximately. Although there are quite some differences in the workability and weldability of the various types of low alloy high-tensile steels, some of them being air hardening, types that are easy to work and weld are available. Most of these steels have from two to six times as much resistance to atmospheric corrosion as has low carbon open hearth steel.

In car design, welding is also used to good advantage in building up parts that in the past have been castings. The striker, carrier iron and front draft lugs in the American Railroad Association design of box cars are of cast steel. These are rather intricate castings and must be firmly secured to the center sill construction, either by riveting or by welding. A substantial weight saving as well as a liberal reduction in cost can be obtained by building up these parts from drop forgings and rolled steel through the use of welding.

The center filler and rear draft lugs are also examples of the economies and design advantages of welded construction. By using rolled steel shapes and plates a welded construction that is both lighter and less costly can be made that will distribute the loads and shocks in a much better manner than is possible with the cast steel design. Through the entire design of railroad cars, both passenger and freight, it holds true that welding permits lighter weight, eliminates loss of strength resulting from rivet holes and finally gives a much better balanced structure. In addition, the use of spot welding instead of riveting for attaching the side sheets gives a perfectly smooth exterior surface which has numerous advantages. The smooth surface decreases wind resistance, makes a more pleasing appearance and finally makes it easier to keep the surfaces clean with little attention.

The modern passenger train car for high speed service, equipped with all the improvements necessary for the safety and comfort of the travelling public, could not be economically operated at the higher speeds prevailing today unless there be a drastic reduction in weight as compared with the cars of a decade ago. Welding, the use of materials with a high strength-weight ratio for the highly stressed members, the use of light weight materials such as aluminum for interior trim and appointments, have all contributed to making possible the stronger, safer and lighter de luxe passenger cars now being built for the American railroads. But this would have been impossible without the essential ingredient for any outstanding engineering accomplishment, namely, a balanced design that uses to best advantage the materials and production processes available and coordinates the design with the requirements for most economical production.



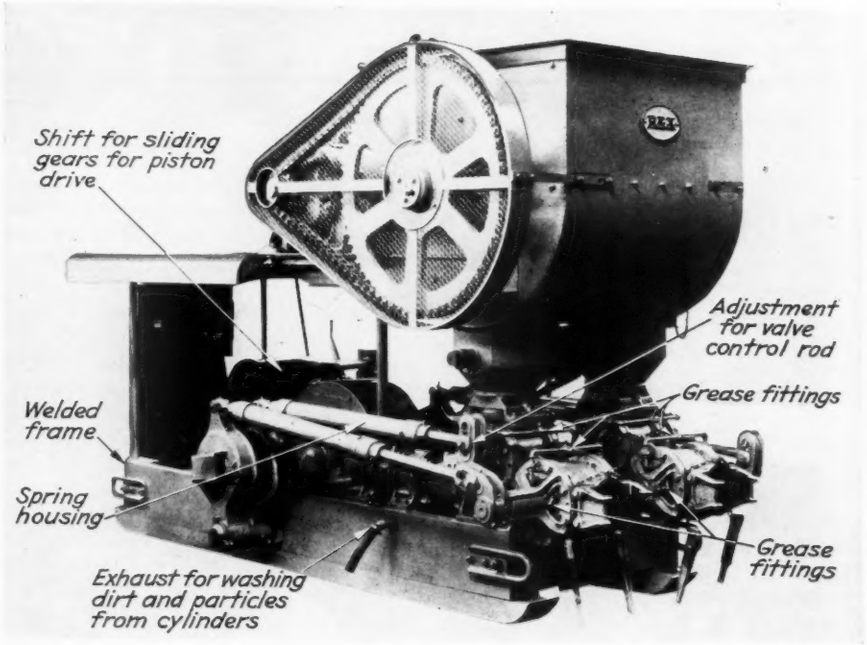
*Arc-welded center sill and close-ups of the end constructions. Two special Zee sections are butt welded together on an automatic arc welding machine to form the main member*

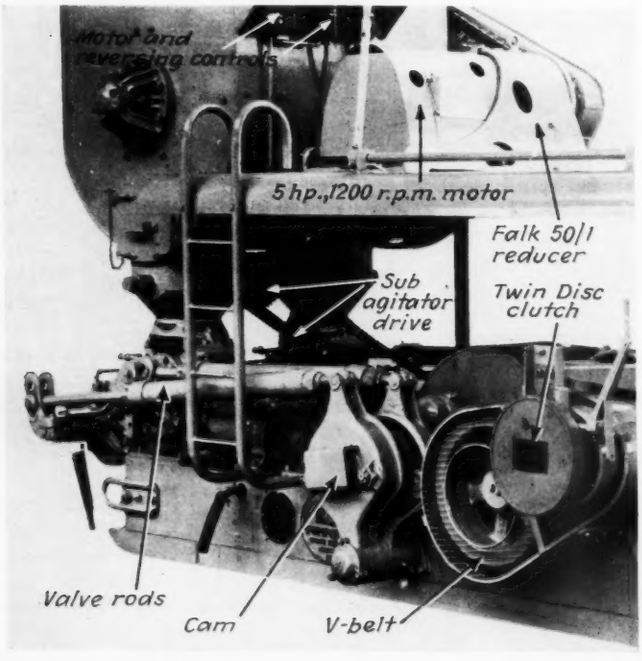
# Modern Designs

## Single or Dual Operation of Cylinders in Concrete Pump

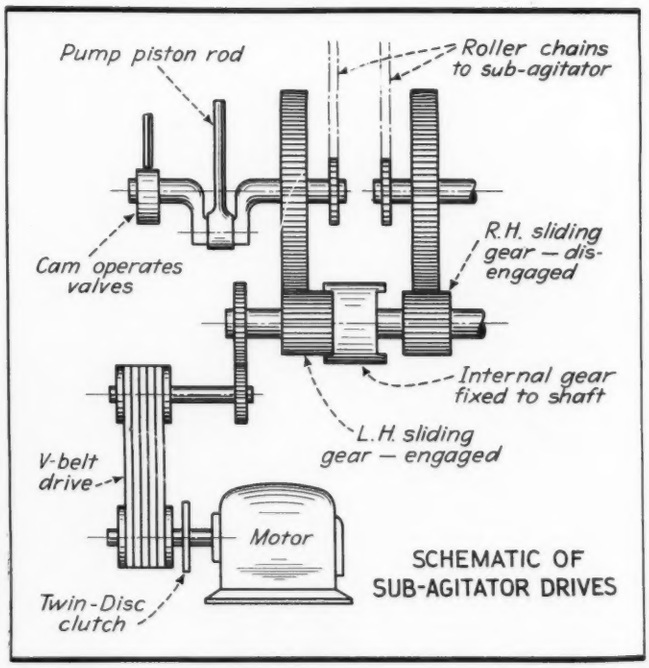
PUMPING of a semi-fluid, abrasive and relatively incompressible material like concrete presents problems in the choice of materials to withstand wear, valve and piston design that will handle an almost-solid material and will not jam, and provision in the driving mechanism to prevent damage in case of overload or stalling.

In this Chain Belt Pumpcrete concrete pumping unit, heat-treated alloy steels are used for all parts contacting concrete, and the pistons are fitted with molded rubber ends; areas of inlet and outlet valve ports are nearly as large as cylinder cross-section, and there are no sharp corners and sudden changes in direction. Slippage in the friction clutches and in belt drives protects working parts and drive gearing when stalling occurs. Two sub-hopper agitators keep concrete uniformly mixed.

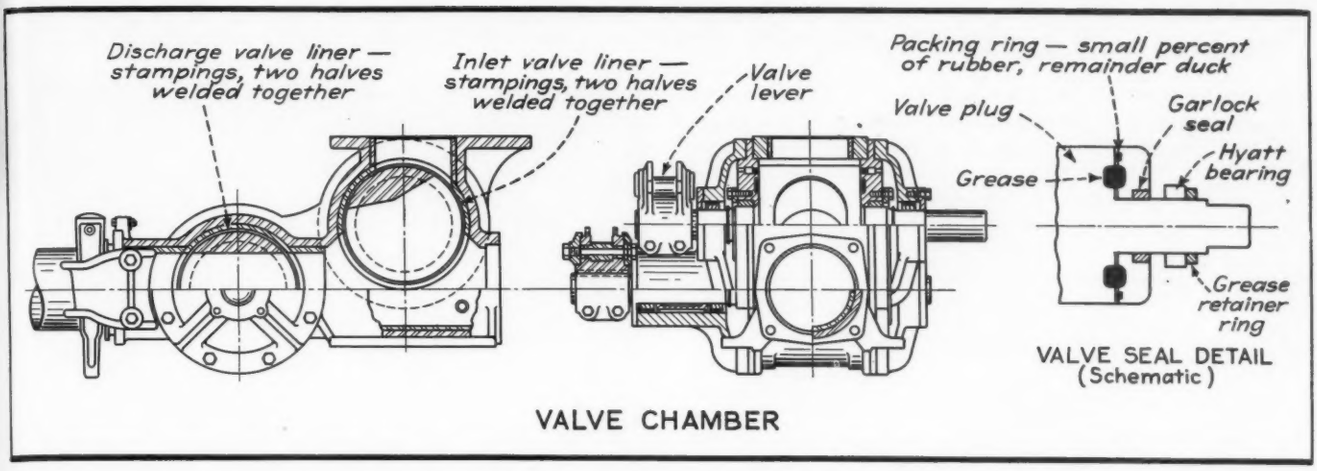

Shift for sliding gears for piston drive
Adjustment for valve control rod
Grease fittings
Welded frame
Spring housing
Grease fittings
Exhaust for washing dirt and particles from cylinders



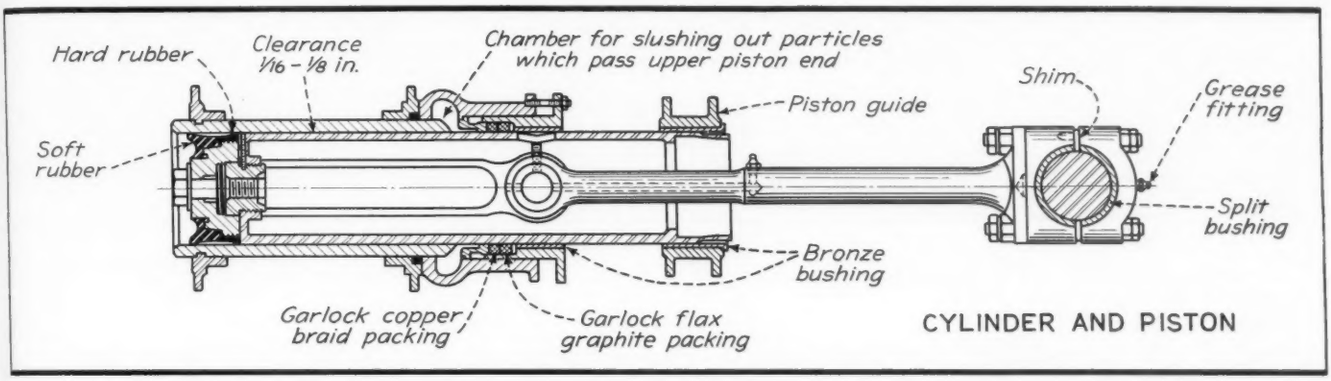

**Case-hardened cams** mounted on the crankshaft operate the spring-relieved valve rods. Case-hardened cam rollers of S.A.E. 4815 steel are fitted with needle bearings. Valve outlet rods are spring pre-loaded to 2,000 lb., inlet rods have double-acting springs preloaded to 1,700 lb., to prevent breakage.



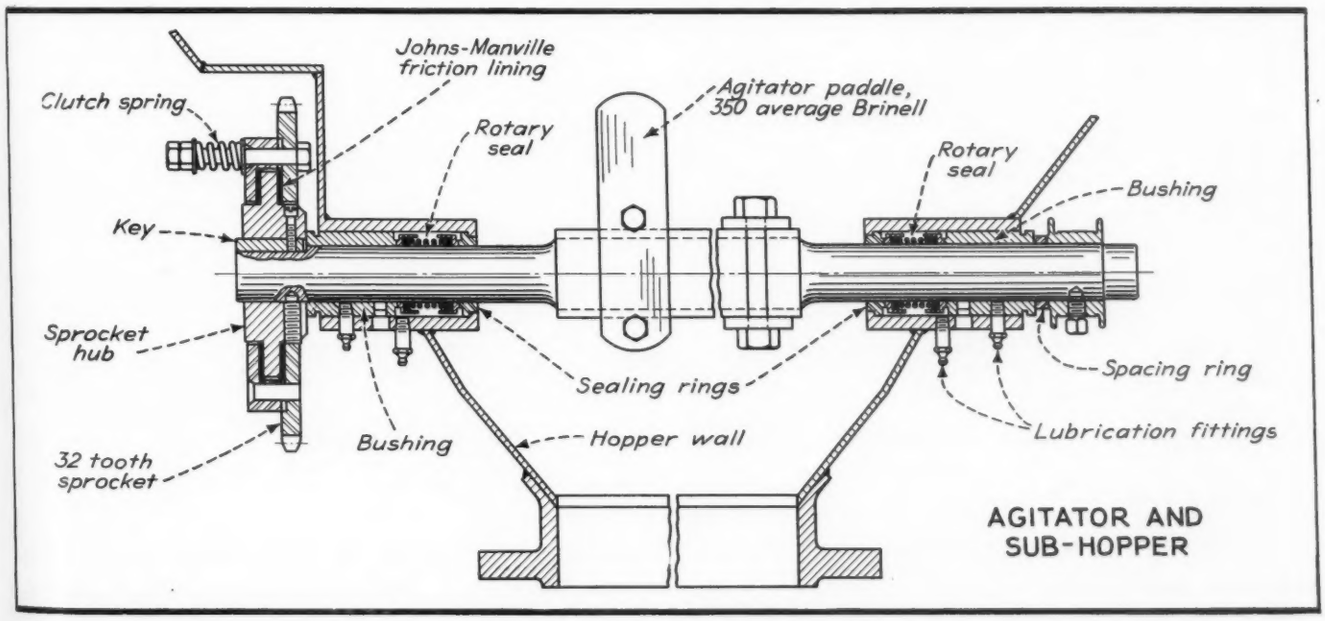

**Schematic of single or dual drive** to sub-hopper agitators and cylinders. Sliding gears, moved in or out of mesh by hand levers, transmit power from double internal gear keyed on the counter-shaft to pinions and to roller chains driving sub-hopper agitators. Countershaft is driven by helical gears and V-belts.


Discharge valve liner — stampings, two halves welded together
Inlet valve liner — stampings, two halves welded together
Valve lever
Packing ring — small percent of rubber, remainder duck
Valve plug
Garlock seal
Hyatt bearing
Grease
Grease retainer ring
VALVE SEAL DETAIL (Schematic)
VALVE CHAMBER

**Valve chambers** are cast steel and are fitted with replaceable liners around the plugs. Plugs are cast of S.A.E. 6150 steel heat-treated to 425-450 Brinell. The liners are half-cylinders stamped from alloy plate stock, welded into a sleeve. Stub shafts are supported on roller bearings. Grease under pressure prevents leakage at shaft seal of valve chamber.



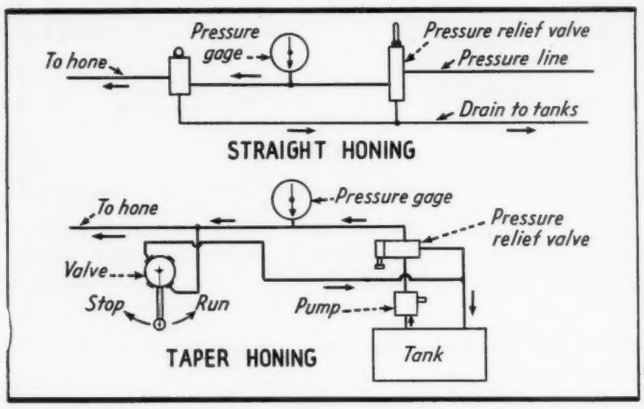

**Replaceable rubber piston end,** similar to type for mud pumping, pushes concrete. Piston proper has $\frac{1}{16}$ in. clearance. Piston skirt and cylinder wall are continuously rinsed with wash water. Replaceable liners are of alloy steel or centrifugally cast of Ni-Cr-Moly iron heat-treated to 500 Brinell. Dihard with a Brinell of 850 is also used for liners.



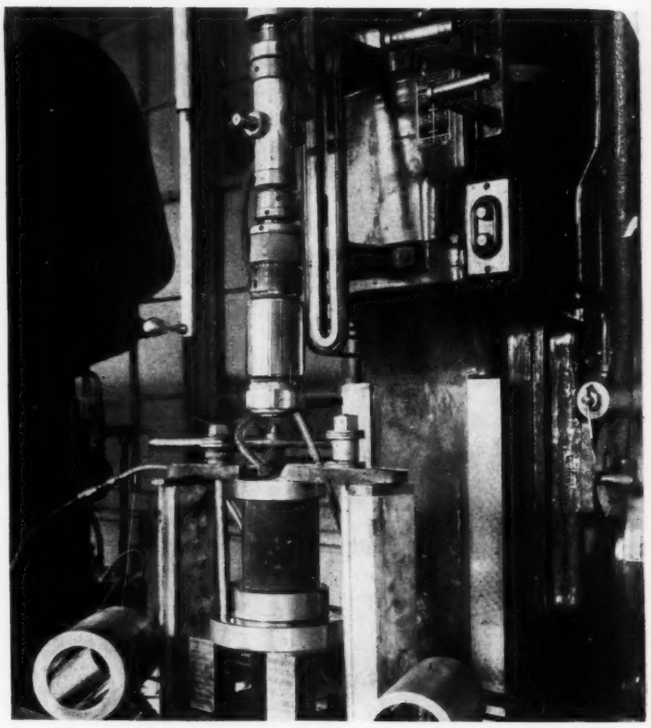

**Sub-hopper agitator** shaft is roller-chain driven. A friction clutch, spring-loaded, protects drive should large aggregate jam agitator paddle. Agitator paddles are hardened to 350 Brinell and are renewable. Hopper is welded steel.

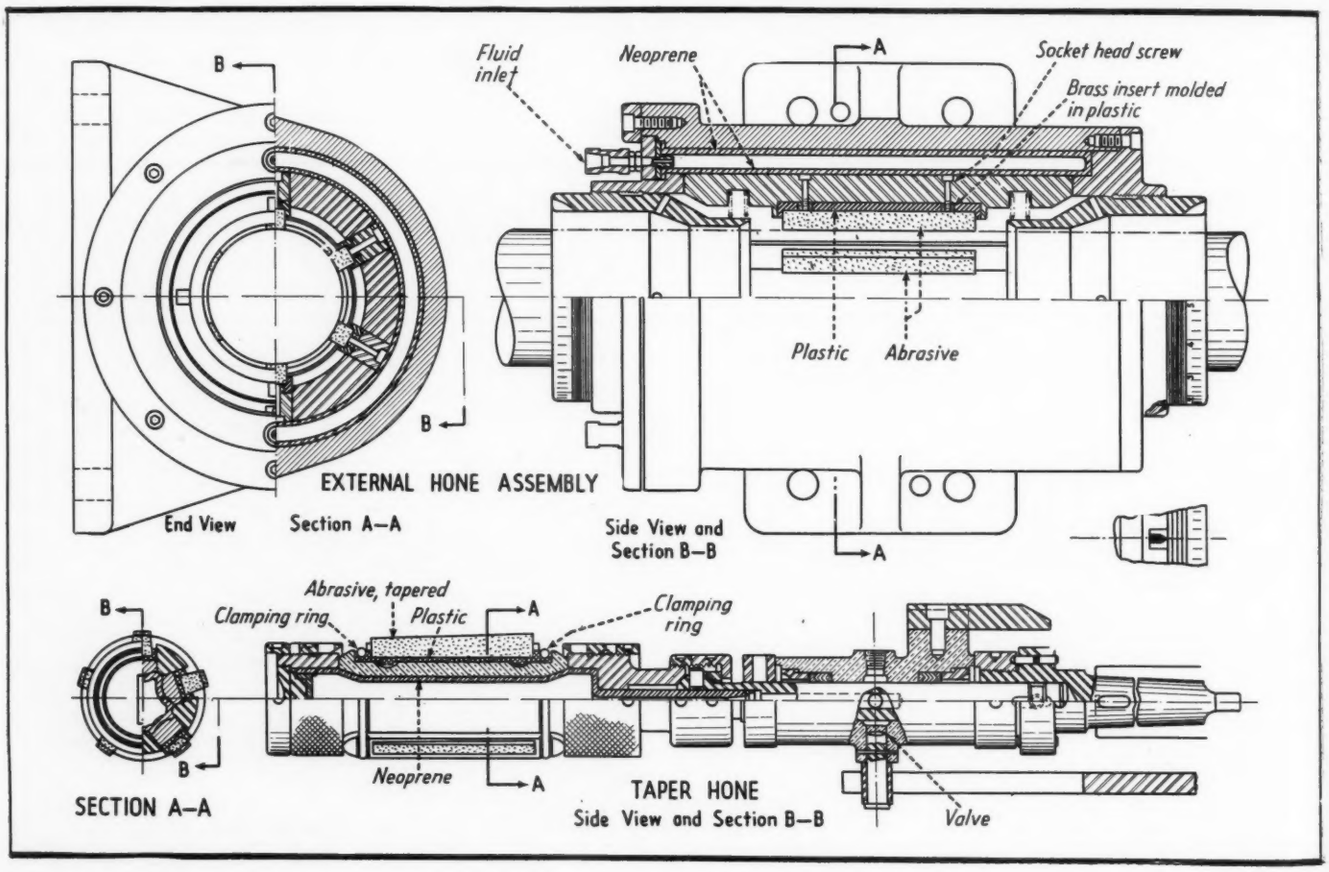
# MODERN DESIGNS — Synthetic Rubber Pressure Tube

**ABRASIVE STONES** are held against work in the external and internal hones designed by Chapman Hone Company by internal pressure applied to a neoprene tube. Hydraulic or pneumatic pressure may be used. Construction permits tapered honing on both internal and external work on any standard machine.



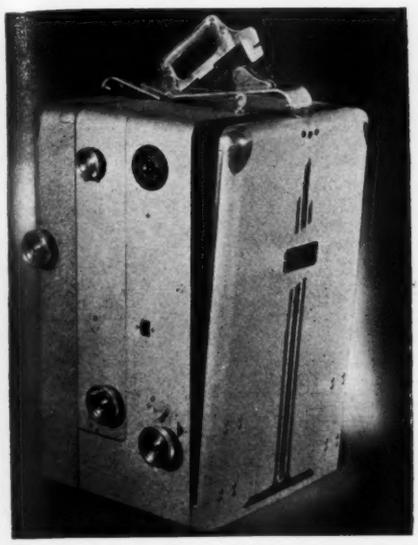

**Schematic of control circuit** for applying pressure to the neoprene tube. This design maintains a uniform pressure distribution against the work resulting in more uniform stone wear, and permits exact control of stone pressure against work.

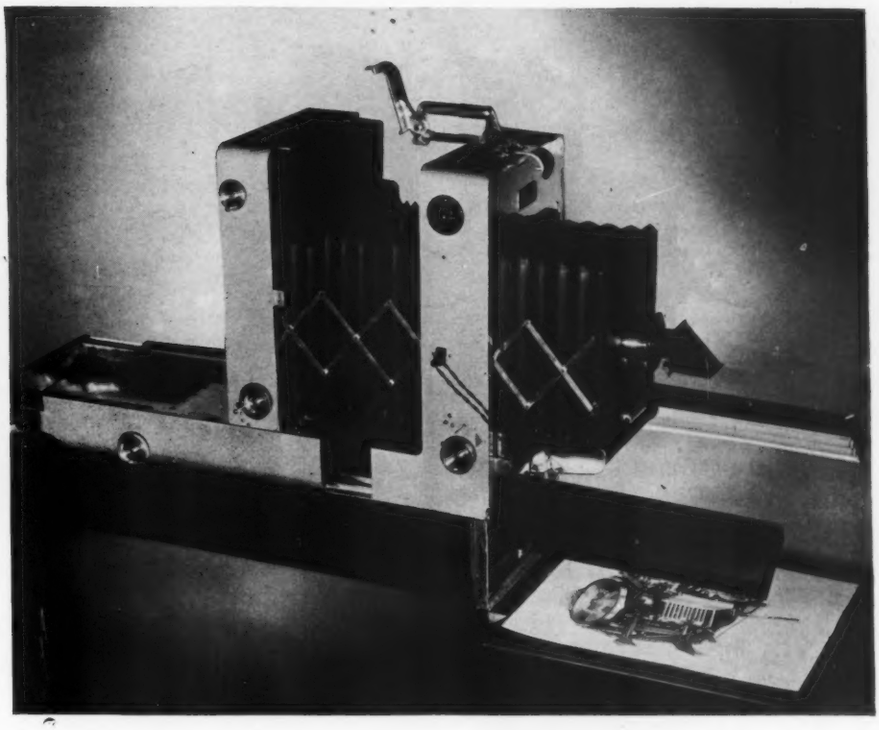





**Plastic sole plates** are molded around the abrasive stones. In the external hone threaded inserts are also molded in the plastic; these are used to attach the sole plate to the sliding block by means of socket head screws. For the taper hone, the plastic plate is molded with a shoulder; the stone assembly is then held in position against the sliding plate by clamping rings which fit against the plastic shoulder, molded in the plate. Hones can be used on any standard machine.

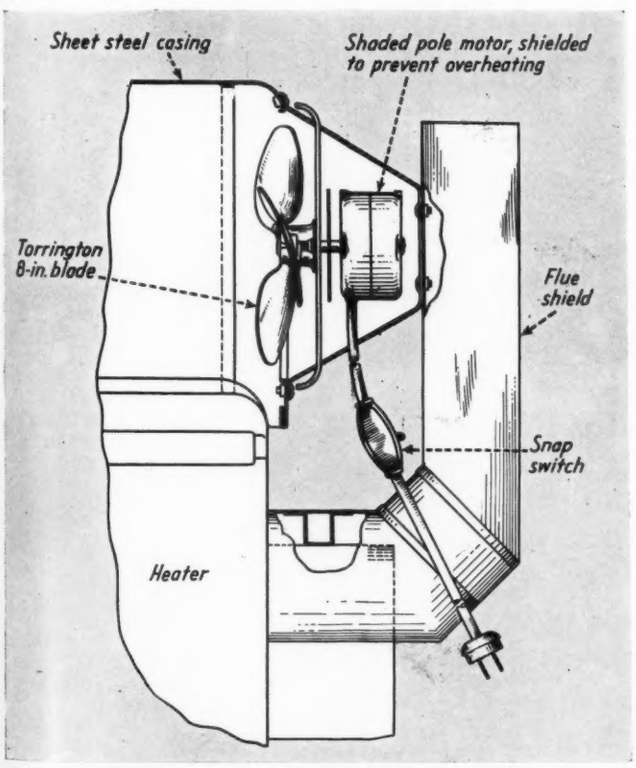
# Completely Self-Contained Reproducing Machine



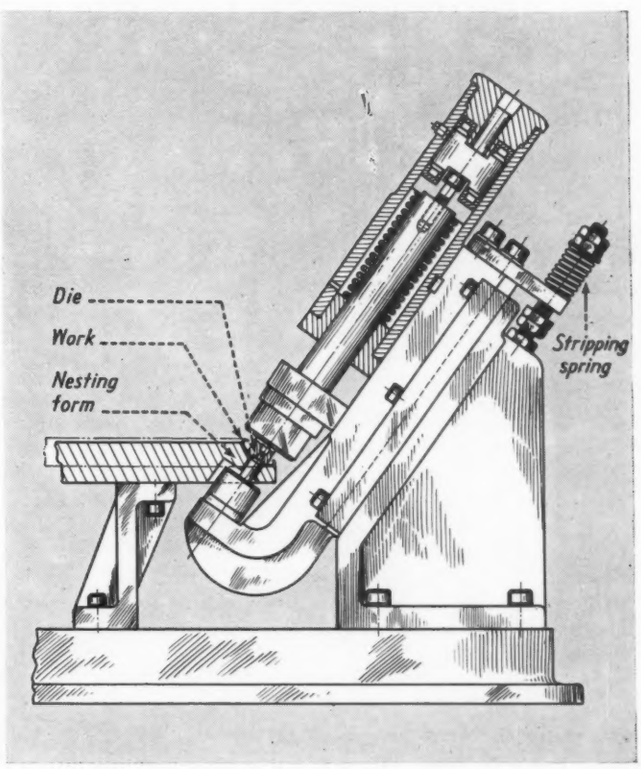


**Portable Fullertone** has a built-in 5 qt. stainless steel tank for carrying developer; wrinkle-finished cabinet has storage space for lighting equipment. Loads with 200 ft. sensitized paper. Movable parts run on ball bearings.

# Heat Distributor Unit; New Hydraulic Punch



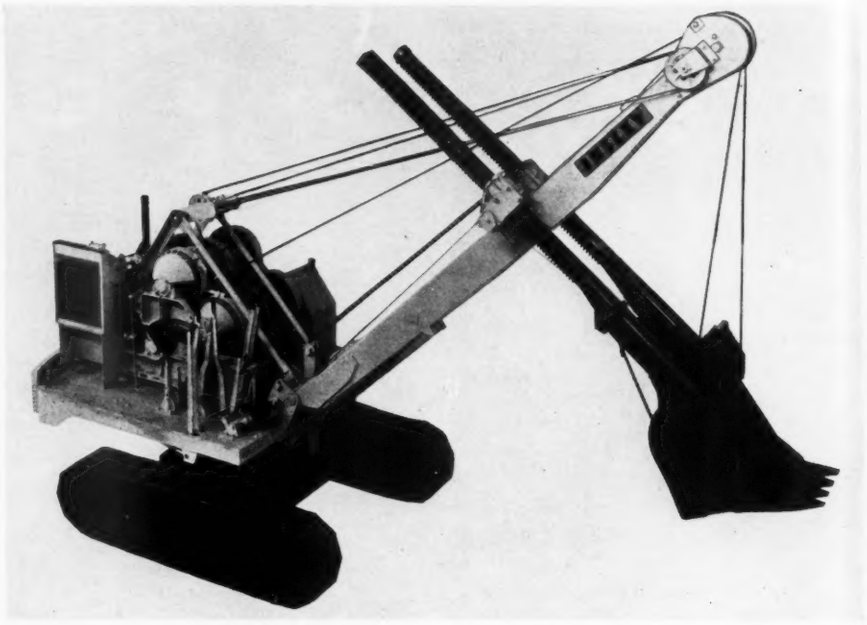

**Forced air circulator** to improve heat distribution of oil-burning space heaters. Built by the Florence Stove Company, the unit, a three-bladed fan and 30-watt motor in a wrinkle-finished drawn steel housing, attaches to top of heater.



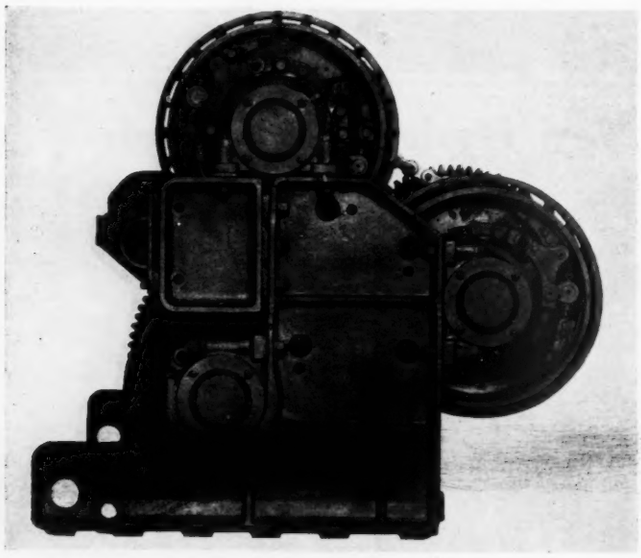

**Hydraulic pressure** applied to this Progressive Welder punch first brings die against work. As pressure builds up, reverse movement of cylinder punches work. The stripping spring retracts punch, nesting form acting as stripping plate.

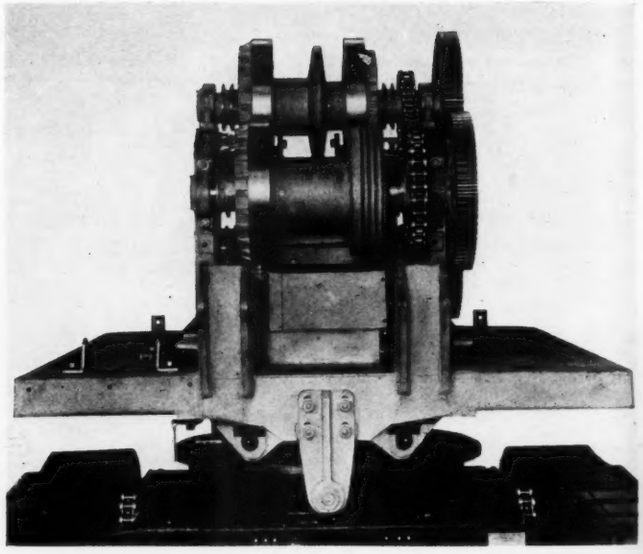
# MODERN DESIGNS — Main Frames and Boom Welded

POWERED with gas or diesel engine or with electric motor as desired, the Insley excavator is a full-revolving machine of the crawler type made in $\frac{3}{8}$ cu.yd. and $\frac{1}{2}$ cu.yd. capacities. The upper revolving frame may be truck-mounted when full load handling capacity with high mobility is desired. All shafts and drums are mounted on shielded bearings protected by dust seals.

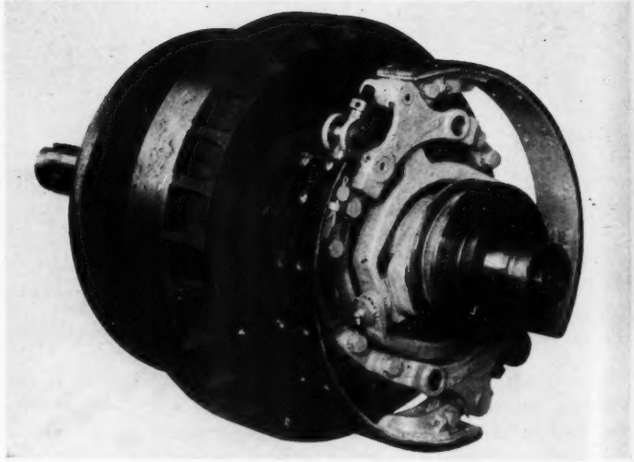


**Two speeds** are provided in the transmission: low for operation of digging machinery and for slow travel at $\frac{7}{8}$ mi. per hr. and high speed for travel at $2\frac{3}{4}$ mi. per hr. All drive shafts are alloy steel heat-treated to obtain maximum toughness. All gears except the pair of bevel gears in carbody are heat-treated cast alloy steel with machined teeth.

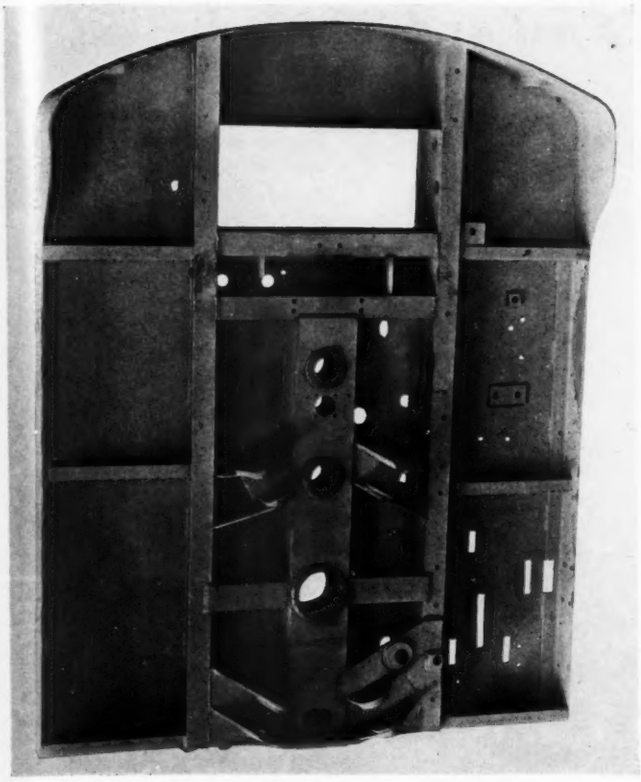




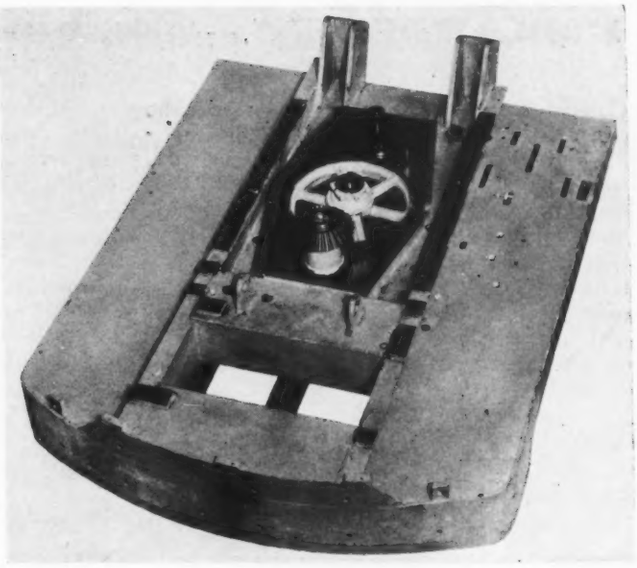
**Shielded ball bearings** protected by labyrinth seals support drums and shafts. Front drum which operates dipper stick is reversible. It is gear-driven through a clutch on one side, for retracting; drive in reverse direction, used for crowding, is through a clutch and chain drive on the opposite end of the drum. When used with dragline attachment, the double-drive drum allows two digging speeds. Chain drive gives high line pull at slow speed; gear drive gives high line speed and less line pull for digging in lighter materials and for handling backfiller blade.



**Balanced internal-expanding clutch** having two half-wrap bands requires less than 5 lb. lever pull for complete engagement. Feel is so sensitive that full load or light load may be suspended in mid-air by slipping clutch and without the use of drum brake. This construction avoids the eccentric loading of drum bearings caused when full-wrap clutch bands are used.



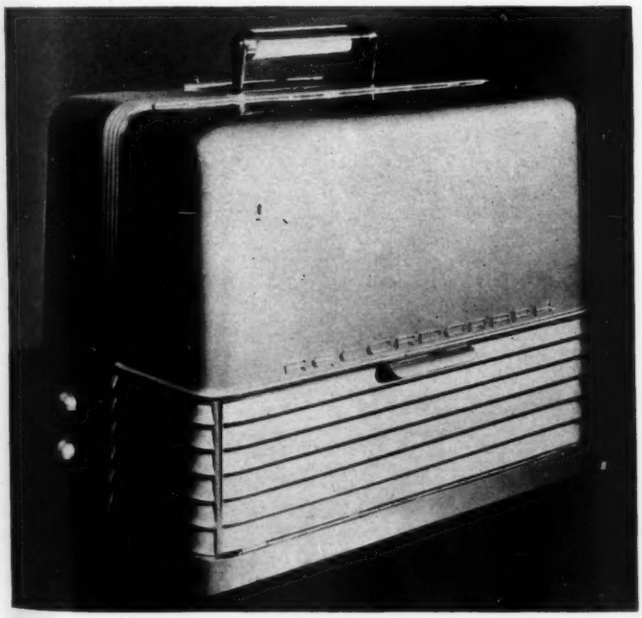
**Revolving frame** is of all-welded construction. Horizontal gears are inclosed in an oil-tight case to which pressure lubrication is supplied by a cam-operated oil pump driven from the engine. An opening in the rear of the welded frame is located under the engine permitting easy removal of the engine oil pan.

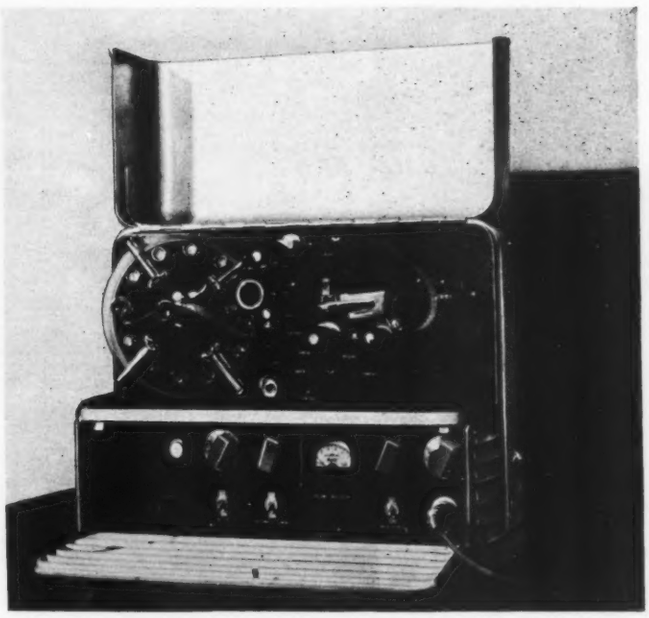


**Top view** of welded revolving frame. Horizontal gears of heat-treated alloy steel run in an inclosed oiltight housing.

CHROME-PLATED BERYLLIUM COPPER cold-forged and heat-treated is used for Bard-Parker surgical knife handles. Nickel silver lacked necessary strength; stainless steel corroded in the sterilizing baths and the rust tended to strike through the chrome-plating. In addition stainless steel was expensive and difficult to work. Beryllium copper was found to have satisfactory strength and non-corrosive properties.

# Desk Unit Records Dictation on Film

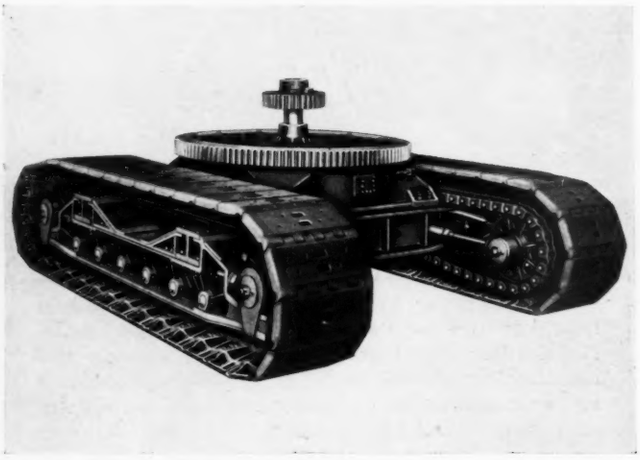




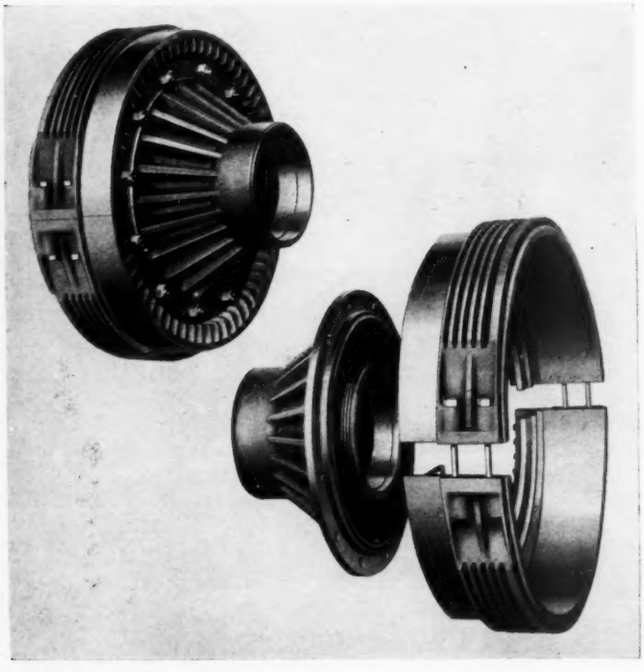
**Dictation electrically recorded.** The Recordak, developed by Wm. L. Wolf and styled by Howard Ketcham, is basically a compact sound-track recording and playback device. ighty parallel grooves 0.002 in. wide can be cut on the 33 mm. du Pont film; a 21 ft. roll suffices for five to six hours dictation. Control knobs are Plastacele; combination handle and indirect light is molded of Lucite. Sheet steel housing has two-tone Hilo metallic finish, chrome-trimmed.

# MODERN DESIGNS — Combined Cast and Welded

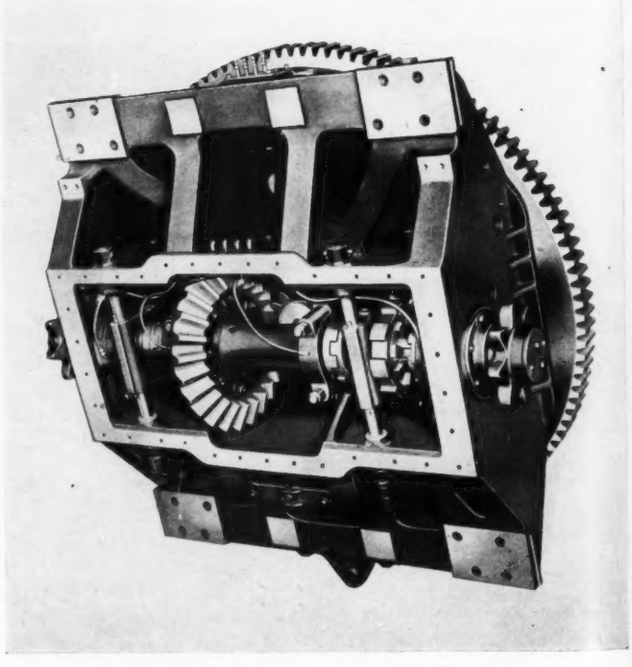
CONSTRUCTION in the Thew Lorain shovels consists principally of formed and welded steel sections combined with steel castings. The boom side members are two pressed channel sections welded into a rectangular tube and supported at the center by a steel casting housing the shipper shaft. X-bracings of H-beam section below this point provide resistance to side deflection and torsion. The entire boom is electric-welded together. Dipper stick is an all-welded structure of rectangular cross-section. Wide flange H-beam sections support the carbody. Crowd rack is drop-forged.



**Full length tread support** is furnished by a T-rail welded to the side frame, reducing wear on tread pins. Side frame is made up of two electrically welded composite girders. Drop-forged rollers have neoprene seals. Shoes are steel castings.



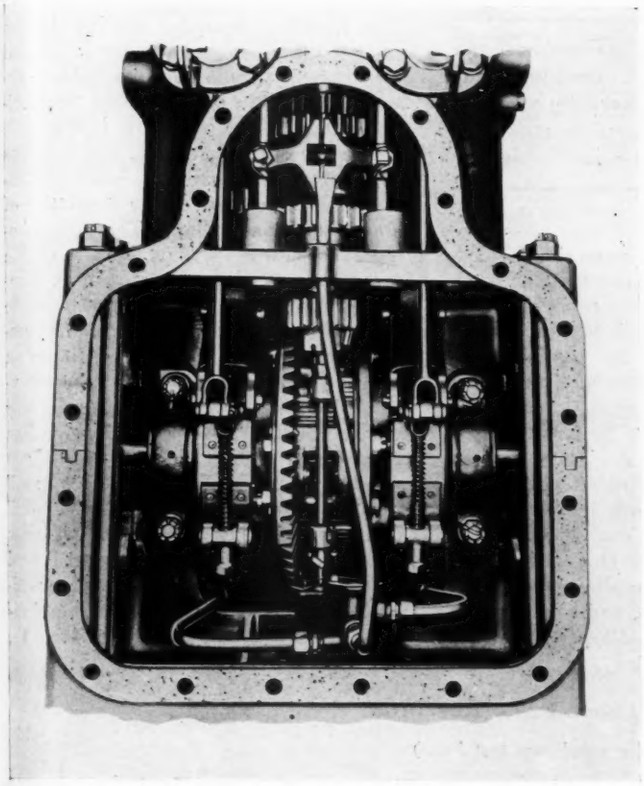
**Swing drums** are of two-piece design. Bevel gear and clutch hub are integral and are cast of manganese-molybdenum steel. The split, clutch friction rings are nickel-molybdenum cast iron. Clutch linings are mounted on reversible bands.



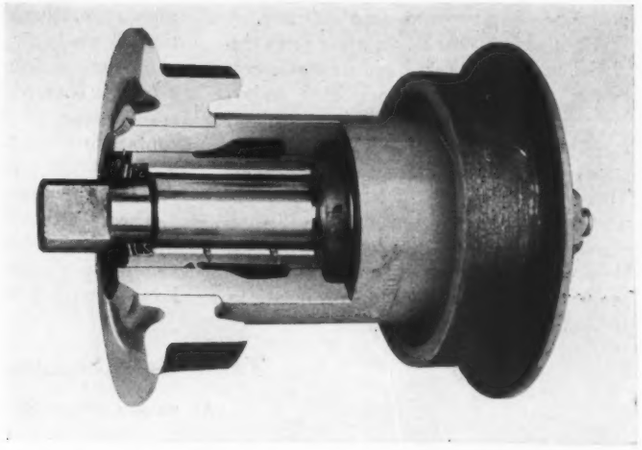
**Pressure lubrication** is provided to each shaft bearing through centralized grease leads. Propelling and steering mechanism is fully inclosed and runs in an oil bath. Ratchet and double pawl on crawler drive shaft act as safety lock.

# Differential Steering, Forged Shoes and Rollers

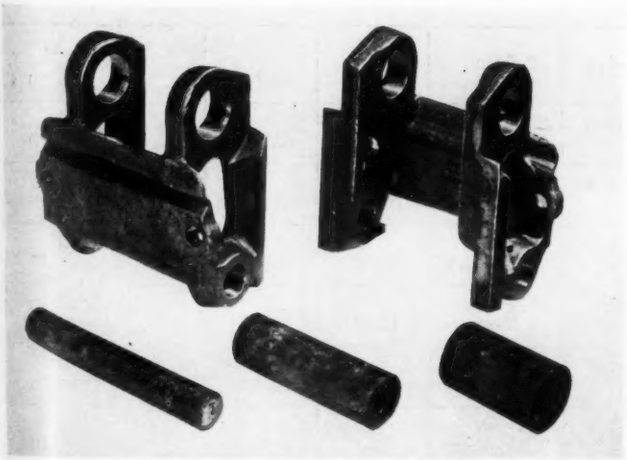
ROLLED SHAPES riveted to transmission and differential casting make up the main frame of the new Cletrac tractors. Front end of main frame is carried on two heavy longitudinal springs supported on trunnions in front castings of track frames. Anti-friction bearings, pressure lubrication and sealed shafts are features.



**Controlled grey iron casting** houses transmission and differential steering mechanism. Final drive is pressure-lubricated by gear pump. Dead axle supports tractor weight on track frame, protects driving mechanism from road shocks.



**Drop-forged rollers** are protected by double leather seals. Inner seal is barrel-flanged leather packing held by phosphor-bronze coil spring. Outer seal cover is crimped over inner seal making a single assembly for close press fit in retainer.



**One-piece, drop-forged shoes** have heat-treated wearing faces. Track shoe pins and bushings are carburized and hardened to provide hard wearing surface and shock-resistant core. Bushings are pressed in place under 40,000 lb. pressure.

**Differential-drive gears** are machined from chrome-nickel steel. All shafts are alloy steel, supported on ball bearings. The entire assembly operates in a bath of oil. Double disk clutch can be removed as unit without disturbing transmission.

# ALUMINUM BRONZE

## *Effect of Composition on Design Use*

W. W. EDENS
*Chief Metallurgist, Ampco Metal, Inc.*

MAKING one specification cover the entire group of aluminum bronze alloys is as difficult as making one S.A.E. composition of chrome-nickel steel serve for all steel applications. Such a restriction would mean the serious omission of many other valuable steels that are now accepted as more or less standard for certain applications. In a similar manner, although not generally realized, one specification for aluminum bronze means the serious omission of other compositions of value to modern industry.

Aluminum bronzes as a class are valuable because of their high strength, corrosion resistance, hardness, high endurance limit or resistance to fatigue, high resistance to impact, good bearing properties and excellent resistance to wear. These properties are of interest and importance to the design engineer when choosing an alloy for a definite purpose. However, with such a multiplicity of properties to be considered, specifications more exact than the general classifications of aluminum bronze must be used.

**VARIATIONS as small as one-half per cent in aluminum content may change physical characteristics so much that an otherwise good design may become ineffective**

Aluminum bronzes are copper-base alloys, containing some 5 to 14 per cent aluminum, along with the possible addition of up to 5 per cent of a third element such as iron, manganese, nickel, or a combination of them. By far the greatest tonnage of cast aluminum bronzes contain iron as the third alloying ingredient so this article will be confined to the iron-bearing aluminum bronzes.

These are usually classified under two headings: low-iron alloys containing about 1 per cent iron, and high-iron alloys containing 2.5 to 4.5 per cent iron. The high-iron material usually has a smaller grain size, greater hardness and greater resistance to wear. In Table I are listed some of the existing standard specifications for these aluminum bronzes.

The equilibrium diagram, Fig. 1, shows approximately the effect of aluminum content and temperature on the properties of aluminum bronze alloys. The microphotographs show the six possible crystalline arrangements when the aluminum content lies between 9 and 14 per cent. Note that the micro-structures are various combinations of the following crystals: a ductile "alpha" crystal which has a maximum hardness of 115 Brinell; a harder and less ductile "beta" crystal which has a maximum hardness of 240 Brinell; a still less ductile matrix of small "alpha" and "delta" crystals called a "eutectoid" structure which has a maximum hardness of 270 Brinell; and a very hard and brittle "delta" crystal which has a maximum hardness of 460 Brinell. Combinations of these forms will have strength,

### Table I—Aluminum Bronze Specifications

**(All values on standard 2-in. sand cast test bars)**

| SPECIFIED BY | SPEC. NO. | ALLOY NO. | CU (PER CENT) | AL (PER CENT) | FE (PER CENT) | IMPURITIES (PER CENT MAX.) | CAST OR HEAT-TREATED | ULTIMATE TENSILE STRENGTH (LB. PER SQ. IN.) | YIELD POINT (LB. PER SQ. IN.) | ELONG. (PER CENT IN 2 IN.) |
|---|---|---|---|---|---|---|---|---|---|---|
| Federal | QQ–B–671 Class A | 1 | 85–89 | 7–9 | 2.5–4.0 | 0.5 Sn 1 others | Cast | 65,000 | ..... | 20 |
| S.A.E. | 68 | 2 | 85–87 | 7–9 | 2.5–4.0 | 0.5 Sn 0.25 others | Cast | 65,000 | 25,000 | 20 |
| A.S.T.M. | B–59–36–A | 3 | 87–89 | 7–9 | 2.5–4.0 | 0.5 Sn 1 others | Cast | 65,000 | 25,000 | 20 |
| A.S.T.M. | B–59–36–B | 4 | 89.5–90.5 | 9.5–10.5 | 1.25 Max. | 0.2 Sn 0.5 others | Cast | 65,000 | 25,000 | 15 |
| Federal | QQ–B–671 Class B | 5 | 89.5–90.5 | 9.5–10.5 | 1.0 Max. | 0.2 Sn 0.5 others | H. T. | 80,000 | ..... | 5 |
| U. S. Navy | 46–B–186 | 6 | 85–89 | 7–9 | 2.5–4.0 | 0.5 Sn 0.25 others | Cast | 70,000 | ..... | 25 |
| General Motors | 4040–M | 7 | 87–89 | 9–11 | 1.5–2.5 | 0.5 Sn 0.25 others | Cast | 70,000 | 37,500 | 18 |
| Air Corps | 11076 | 8 | 78 Min. | 10.5 12.0 | 5 Fe Max. 5 Mn Max. 5 Ni Max. | 0.2 Sn 0.5 others | H. T. | 85,000 | 200 Brinell | 3 |

ductility and hardness depending on the proportion of each type of crystal in a particular structure. As indicated by the diagram this will depend on the aluminum content and the temperature at which transformation in grain structure ceases.

To illustrate the effect of these two factors on the crystalline formation and consequently the physical properties of an aluminum bronze, assume a casting with aluminum content of 11 per cent. If its rate of cooling is so rapid that transformation is completed at 1,600 deg. F. it will have a structure similar to that shown in Fig. 1(b) with a maximum possible hardness of 240 Brinell. However, if the cooling rate is such that transformation in structure progresses to a point equivalent to quenching at 1,200 deg F. the ductility will be increased because the structure has changed to one containing ductile "alpha" crystals similar to that shown in Fig 1(c). Hardness will be less than 240 Brinell depending on percentage of ductile "alpha" formed. If transformation continues below 1,058 deg. F. because of very slow cooling the micro-structure will be similar to that shown in Fig. 1(d). Hardness of the bronze may reach 270 Brinell and it will be brittle.

Now suppose a casting of such form that the cooling rate is very rapid, thus limiting the transformation at a point equivalent to a quench at a temperature about 1,500 deg. F. With an aluminum content of 7 per cent the material will be comparatively ductile and will have an appearance similar to that in Fig. 1(a), with a maximum hardness of about 115 Brinell. If the aluminum content be increased to 9 per cent the physical properties will be improved and the structure will be similar to that shown in Fig. 1(c). Addition of 2 per cent more aluminum would make a material similar to the "beta" structure shown in Fig. 1(b), which would have still less ductility and higher hardness values, up to 240 Brinell.

With an aluminum content above 11.8 per cent, aluminum bronze is of such hardness that it has only a limited number of applications. Some of these are

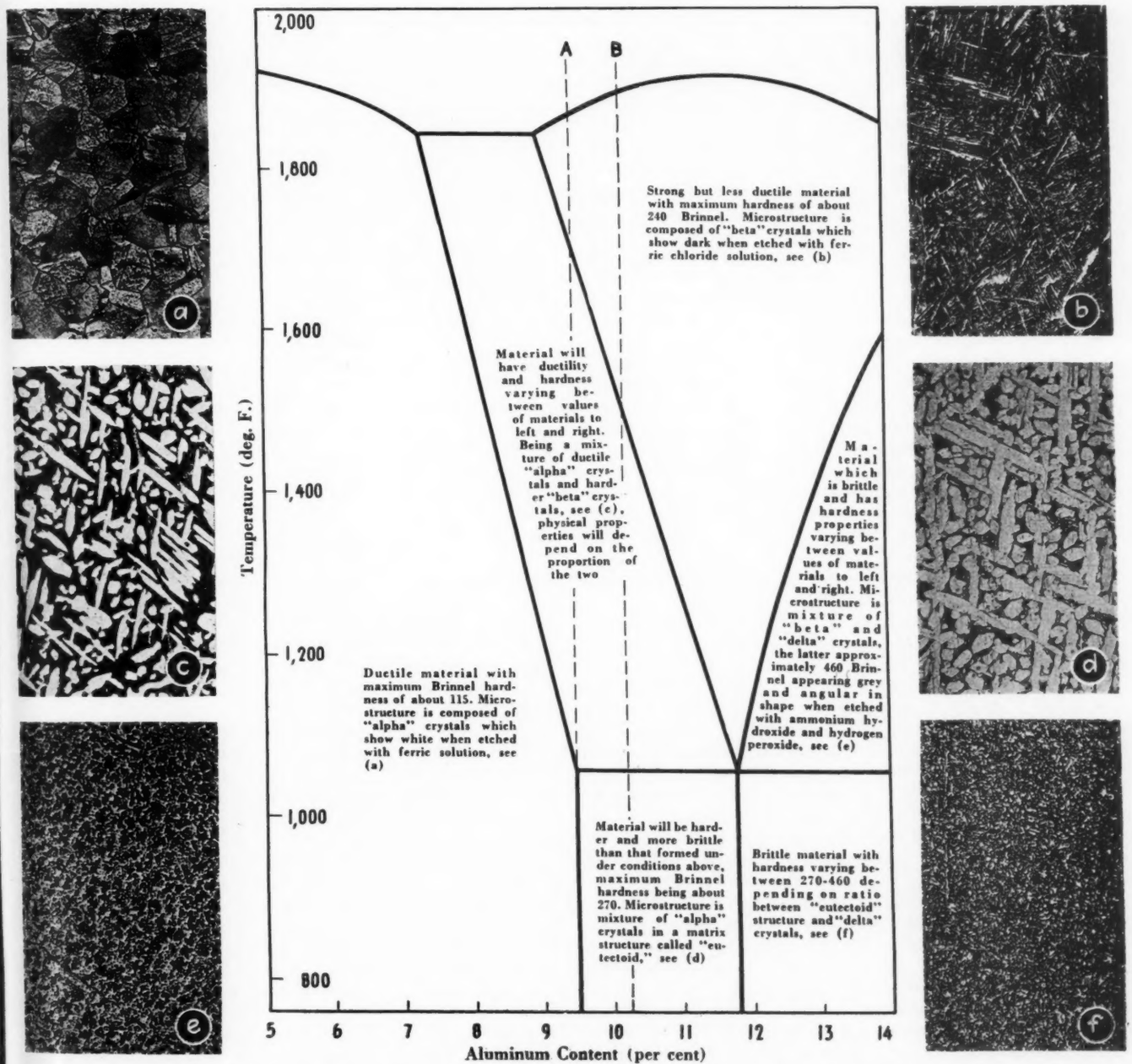

2,000
1,800
1,600
1,400
1,200
1,000
800
Temperature (deg. F.)
A
B
Strong but less ductile material with maximum hardness of about 240 Brinnel. Microstructure is composed of "beta" crystals which show dark when etched with ferric chloride solution, see (b)
Material will have ductility and hardness varying between values of materials to left and right. Being a mixture of ductile "alpha" crystals and harder "beta" crystals, see (c), physical properties will depend on the proportion of the two
Material which is brittle and has hardness properties varying between values of materials to left and right. Microstructure is mixture of "beta" and "delta" crystals, the latter approximately 460 Brinnel appearing grey and angular in shape when etched with ammonium hydroxide and hydrogen peroxide, see (e)
Ductile material with maximum Brinnel hardness of about 115. Microstructure is composed of "alpha" crystals which show white when etched with ferric solution, see (a)
Material will be harder and more brittle than that formed under conditions above, maximum Brinnel hardness being about 270. Microstructure is mixture of "alpha" crystals in a matrix structure called "eutectoid," see (d)
Brittle material with hardness varying between 270-460 depending on ratio between "eutectoid" structure and "delta" crystals, see (f)
5
6
7
8
9
10
11
12
13
14
Aluminum Content (per cent)
a
b
c
d
e
f

*Fig. 1—Microphotographs show typical structures of aluminum bronze produced by temperature and composition limits indicated for various areas in equilibrium diagram*

forming and drawing dies, wear strips to replace hardened steels and a few others, all of which represent a small fraction of the yearly total of aluminum bronze tonnage.

Below 11.8 per cent aluminum content there are two general types of aluminum bronze; one being ductile because of the predominance of "alpha" crystals, the other being harder and less ductile because of the predominant influence of "beta" and "eutectoid" structure. The transition point between the two lies at about the 9.5 per cent aluminum content line. This division applies to both low-iron and high-iron alloys.

### *The Critical Range*

Perhaps the most common type of aluminum bronze is the familiar 89-10-1 composition, a low-iron alloy. Alloy 5, Table I, gives standard physical properties of this material. It has been customary to limit the aluminum content between 9½ and 10½ per cent. This range is very critical because of its nearness to the transition point between the ductile "alpha" type bronzes and the harder less ductile "beta" or "eutectoid" bronzes. An aluminum content on the low side of the specification gives an "alpha" type bronze with properties similar to those of Alloy 5, Table II. Raising the aluminum content to the high side of this specification by as little as ½ to 1 per cent results in a harder more brittle bronze. Alloy 7 in Table II is typical of this type of alloy.

Low-iron aluminum bronzes are usually supplied in a heat-treated condition. It is in the heat-treatment that slight differences in aluminum content becomes especially important. For example, heating the ductile "alpha" type bronze indicated by dotted line *A* in the equilibrium diagram, Fig. 1, to an elevated temperature will cause the reabsorption of the "alpha" crystals into the harder and stronger "beta" structure. To do this the temperature would have to be raised to 1,740 deg. F. which is beyond a safe commercial heat-treating temperature for this material. At any temperature below that, some "alpha" crystals will always remain. Being the ductile and tough constituent the "alpha" will give the bronze an elongation which is greater than that usually specified for heat-treated 89-10-1 material. The physical properties after a proper drawing operation will be more nearly like those of Alloy 6, Table II. The alloy has high strength with relatively high elongation.

As indicated by line *B* in Fig. 1, in heat-treating the 89-10-1 bronze when the aluminum content is nearer the high side of the specification the material becomes less ductile and harder at a much lower temperature.

On the low side of this specification the ductile "alpha" constituent can never be entirely absorbed with commercial heat-treating practice whereas with a slight addition of aluminum a 100 per cent "beta" structure with higher physical properties can be obtained within ordinary safe working temperatures. It is therefore important to specify definite limits of composition which will insure the desired physical properties without expensive foundry technique. Two distinct alloys, one with aluminum content of 9–10 per cent and the other with an aluminum content of 10–11 per cent, as shown by Alloys 5 and 7, Table II, are suggested as logical selections. While the theoretical division point between these two alloys is at 9.5 per cent the rate of cooling in commercial sand castings causes slight variations in this point.

The 10–11 per cent bronze can be heat-treated to have the properties of Alloy 8, Table II. Its exceptional physical properties make it an ideal material for severe applications where sudden and drastic overloads occur, and where the installation is subject to abrasive conditions from foreign particles such as mill scale, sand and similar material. In equipment that does not get enough attention from the maintenance crew and are subjected to severe service, the softer alloys quickly "chew out" from the abrasive actions or mushroom under extreme loading. The abrasion resistance and hardness of Alloy 8 make it suitable for such applications.

Another heat-treated form of this alloy will give physical properties as indicated for Alloy 9, Table II. While this material has certain valuable properties in its favor, its comparatively low elongation definitely limits its usefulness except for a certain few parts which are well backed up, must not squash out and are not subject to distortion under load.

### *High-Iron Aluminum Bronzes*

In the high-iron aluminum bronzes there are now several specifications covering the ductile "alpha" material of which Alloy 1, Table II, is typical. This alloy has good tensile and elongation properties. It is an excellent material for applications in which good elongation with high resistance to shock is necessary, as, for example, parts subject to impact loading.

Adding approximately 3 per cent aluminum will change it to a harder and stronger material as indicated by properties for Alloy 2, Table II. As cast it has somewhat higher physical properties than the "alpha" type alloy by virtue of its greater hardness it resists "squashing out" under comparatively heavy loads. Where elongation is of great importance, and highest possible bearing qualities are required, as, for example, a worm gear working under shock conditions or a bearing working under high unit load, this alloy can be heat-treated to give properties as shown for Alloy 3, Table II. The increase in tensile and elongation properties is achieved somewhat at the expense of the Brinell hardness, but there are many instances in which this material will fulfill application requirements.

Where it is necessary to have a material with exceptionally high tensile strength and proportional limit together with good hardness, even at the expense of some elongation, this same high-iron bronze can be heat-treated to have the properties of Alloy 4, Table II. There is at present no existing general specification for this material in spite of its excellent physical properties and its high wear resistance.

### *Effects of Cooling Rate*

For a given composition of the alloy the physical properties of aluminum bronze casting will depend largely on the cooling rate, unless corrected by later heat-treatment. Increasing the rate of cooling has an effect comparable to an increase in aluminum content; it makes the material less ductile, harder and of higher physical strength.

"Mass effect" is an important factor influencing the rate of cooling. Small castings because of faster cooling will develop a somewhat harder structure than that found in large castings of the identical composition. Where castings are exceptionally small, such as wear strips, small gears and other parts of less than 1-in. section; or extremely large castings such as screw-down nuts and other castings over 3-in. in section, corrective heat-treatment is necessary to insure the desired properties in the material.

Most of the factors which affect the strength of an aluminum bronze casting can be controlled by the foundryman, but it is important that a composition be selected which can most easily give the desired physical characteristics. Differences as small as 0.3 per cent in aluminum content may require entirely different technique in securing the desired properties.

Variations in properties are to be expected in alloys which have an aluminum content ranging between 9.5 and 10 per cent and it is difficult to assure consistently uniform material in successive lots or heats of castings. This lack of uniformity is not only injurious in the final application of the material, but is also important because of its effect on machining time and general fabrication costs.

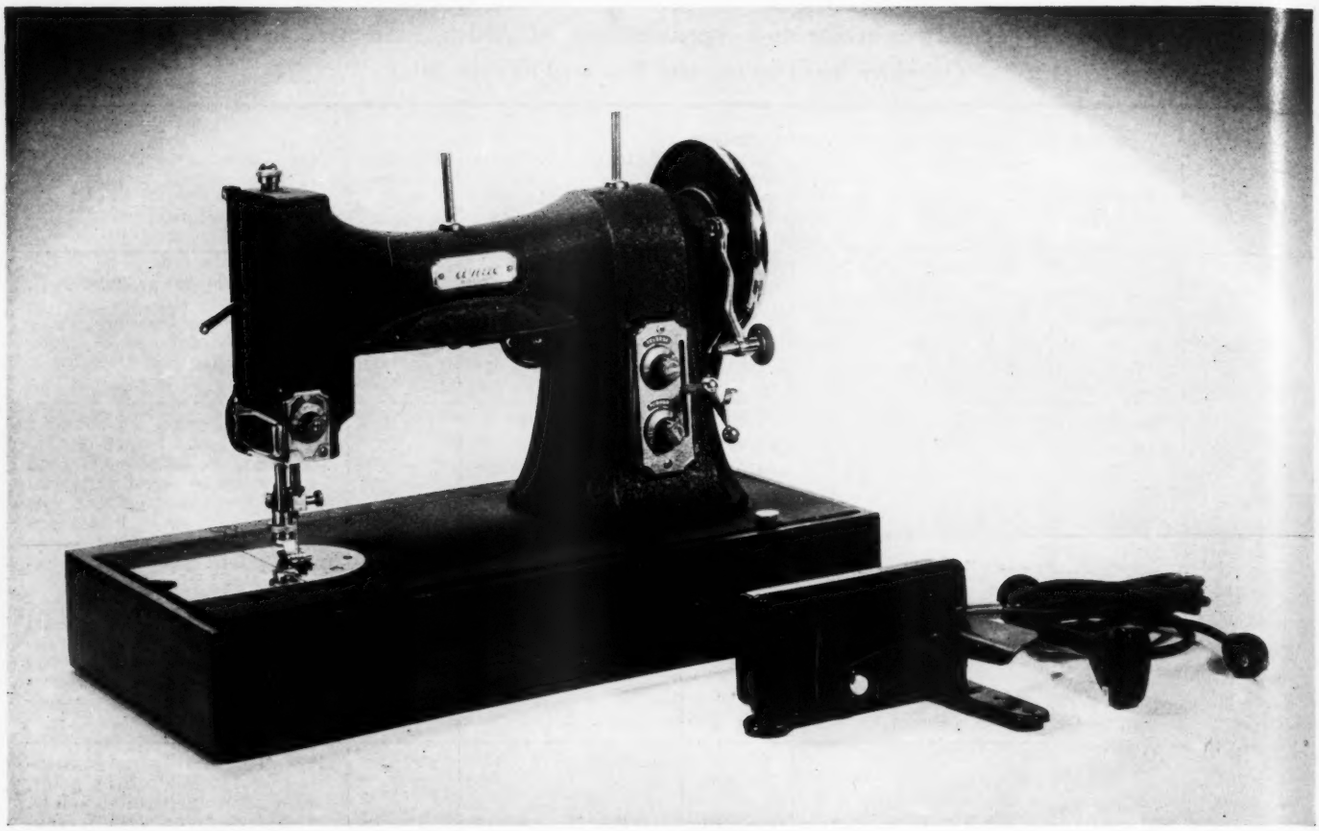
Aluminum bronzes logically fall in two divisions: (1) The definitely low aluminum content ductile types; (2) The higher aluminum content harder and less ductile types. Each may be in the as-cast or in the heat-treated form. They are a series of engineering materials that are admirably suited to many applications.

## Table II—Properties and Applications of Aluminum Bronze

**(All values based on standard 2-in. sand cast test bars)**

| | Type of Structure | Alloy No. | Ultimate Tensile Strength (lb. per sq. in.) | *Yield Point (lb. per sq. in.) | Elongation (per cent in 2 in.) | Brinell Hardness (3,000 kg.) | **Applications |
|---|---|---|---|---|---|---|---|
| High-iron aluminum bronze | Alpha | 1 — Cast<br>% Cu 85–89<br>% Al 7–9<br>% Fe 2.5–4<br>% † (Max.) 1.00 | 65,000–75,000 | 23,000–28,000 | 20–25 | 124–130 | Bearings and gears against S.A.E. 1020. Good elongation, withstands impact loading where stresses do not exceed 15,000 lb. per sq. in. max. |
| | Alpha-Eutectiod | 2 — Cast<br>% Cu 82–86<br>% Al 10–12<br>% Fe 2.5–4<br>% † (Max.) 1.00 | 75,000–85,000 | 35,000–42,000 | 12–18 | 146–166 | Bearings and gears against steel with minimum Brinell of 225. Worm gears under heavy load and shock or speed variation. Good for industrial and salt water corrosion. Endurance limit 35,000 lb. per sq. in. at $10^8$ cycles. Very wear resistant. Good hot strength. |
| | | 3 — Heat-treated | 80,000–90,000 | 35,000–42,000 | 18–22 | 138–159 | Similar to No. 2 where increased elongation is necessary at expense of hardness and 3,000 lb. per sq. in. drop in proportional limit. Good bearing material. |
| | | 4 — Heat-treated | 93,000–100,000 | 43,000–50,000 | 8–12 | 180–200 | High strength Al-bronze combining best tensile, yield point, elongation and hardness values. Used for extreme service conditions of Alloy 2 except for corrosion. Especially good for highly stressed parts. |
| Low-iron aluminum bronze | Alpha | 5 — Cast<br>% Cu 88.25–90<br>% Al 9–10<br>% Fe (Max.) 1.25<br>% † (Max.) 0.50 | 70,000–77,000 | 25,000–32,000 | 30–40 | 115–126 | Soft Al-bronze having exceptionally high elongation properties. Suitable for light members subject to shock, subject to plastic flow under heavy loads because of low Brinell. Good forging properties and good corrosion resistance. |
| | | 6 — Heat-treated | 80,000–90,000 | 40,000–50,000 | 22–30 | 143–156 | Heat-treated variation of Alloy 5 showing increase in physicals retaining good elongation, suited for highly stressed parts where deformation rather than breakage is essential in cases of excessive overloading. |
| | Alpha-Eutectoid | 7 — Cast<br>% Cu 88.25–90<br>% Al 9–10<br>% Fe (Max.) 1.25<br>% † (Max.) 0.50 | 70,000–80,000 | 38,000–44,000 | 12–20 | 131–143 | Low-iron Al-bronze similar in application to Alloy 2 except that while its wear resistance is superior to most bronzes, it is not as good as the high-iron Alloy 2. |
| | | 8 — Heat-treated | 80,000–100,000 | 40,000–50,000 | 12–15 | 163–179 | Heat-treated variation of Alloy 7 showing increased tensile, yield, P.L., and hardness. Used under abrasive condition and has high resistance to squashing out under heaving loading and impact. |
| | | 9 — Heat-treated | 80,000–100,000 | 60,000–70,000 | 5–9 | 187–207 | Heat-treated variation of Alloy 7 showing exceptionally high yield and hardness. Not suited for shock loading but when properly backed up will show best load carrying properties of any of the Al-bronzes. |

† Impurities. * 0.01 elongation. ** General applications of Al-bronze include bushings, bearings, spur and worm gears, feed nuts, corrosion equipment, wear plates and strips, and similar applications where high strength, good wear resistance and long life are prime requisites.



*White Sewmaster portable sewing machine weighs 13 lb. less but in all other respects is exactly the same as a standard model*

# MAGNESIUM FOR LIGHTNESS

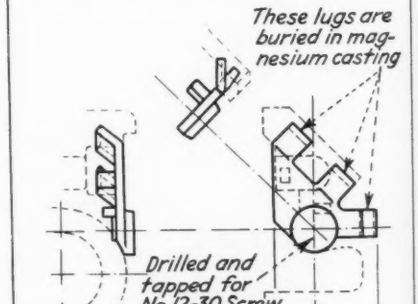
CHARLES E. COLEGROVE
*Chief Engineer, White Sewing Machine Company*

FOR MANY YEARS so-called "portable" sewing machines have been on the market. But the "lightweight" feature of these machines usually was achieved primarily by reduction in size, the same materials of construction as in the standard machines being used throughout. Some of these machines used aluminum to further reduce weight, but the use of lighter materials was secondary, the weight saving being achieved primarily by reduction in size. Such machines are commonly called "three-quarter" or "one-half" size machines.

Evidently a full-sized rotary electric sewing machine, embracing every feature of the finest standard machine, but a truly portable machine, light enough for an average woman to handle and carry with ease, would appeal strongly to many prospective buyers and would have strong selling points. It was primarily for the purpose of creating such a sales opportunity that the White Lightweight Sewmaster was developed.

The overall specifications for the design of the Sewmaster were not difficult to establish. To retain all the features of mechanical accuracy, permanence and durability of the standard unit, the working parts of the new portable model had to be exactly the same as those of the standard full-size machine. This reduced the weight saving possibilities to the redesign of the bedplate and arm of the sewing machine, which are the heaviest elements of the sewing machine. Normally they are gray iron castings.

Considerable weight could be saved by making the base and arm castings of aluminum or of magnesium alloy. The latter, being considerably lighter than aluminum and only one-fifth the weight of cast iron, was selected. A detailed study of the dimensions of the bed and arm was then made to determine if further weight savings could be made by changing their shape or size. It was found that practically nothing could be gained thereby and that any changes in shape or size


These lugs are buried in magnesium casting
Drilled and tapped for No.12-30 Screw during regular machining of casting
1 7/16"
Material: Gray cast iron

*For tapped holes, gray iron inserts in the magnesium casting must be provided if the load on the stud or screw will be too severe for a magnesium thread to withstand. Lugs anchor insert to casting*

would greatly increase production costs.

By adhering to the design and dimensions of the bed and arm of the full-size regular machine it was found that the same pattern equipment as for the gray iron castings could be used for the magnesium castings. However, in order to take care of increased production, new pattern equipment was finally provided. The big economy of retaining the same design as for the gray iron casting came in the savings in tooling and machining expenses. Here was a striking advantage in that production of the Lightweight Sewmaster could be put through the regular production line using the same jigs, fixtures and setups, the only difference being in the shape and clearances of the cutting tools themselves. Cutting lubricant is not used for either cast iron or magnesium and the same feeds and speeds were used for machining both materials. Magnesium can be cut faster than cast iron but considering the volume of production and the shifts in the machining setup that would have been required, it was found that it was more economical to sacrifice the possible gain from the use of greater cutting speeds for magnesium.

Comparing the finished gray iron and magnesium castings, the gray iron bedplate weighs 8 lb. 2 oz., the magnesium alloy bed plate weighs 2 lb. 6½ oz., the cast iron arm weighs 10 lb., the magnesium alloy arm weighs 2 lb. 9½ oz. Thus a total saving in weight of 13 lb. 2 oz. was effected by the change from gray iron to magnesium alloy.

A number of design precautions must be observed when changing from cast iron to magnesium. Magnesium screw threads are not as strong as those of cast iron. Hence small tapped holes for holding studs or screws subjected to serious loads, vibrations or shocks, should not be used. The solution is to tap larger diameter holes, or more holes, or use cast iron or steel inserts. The design for a cast iron insert is shown here.

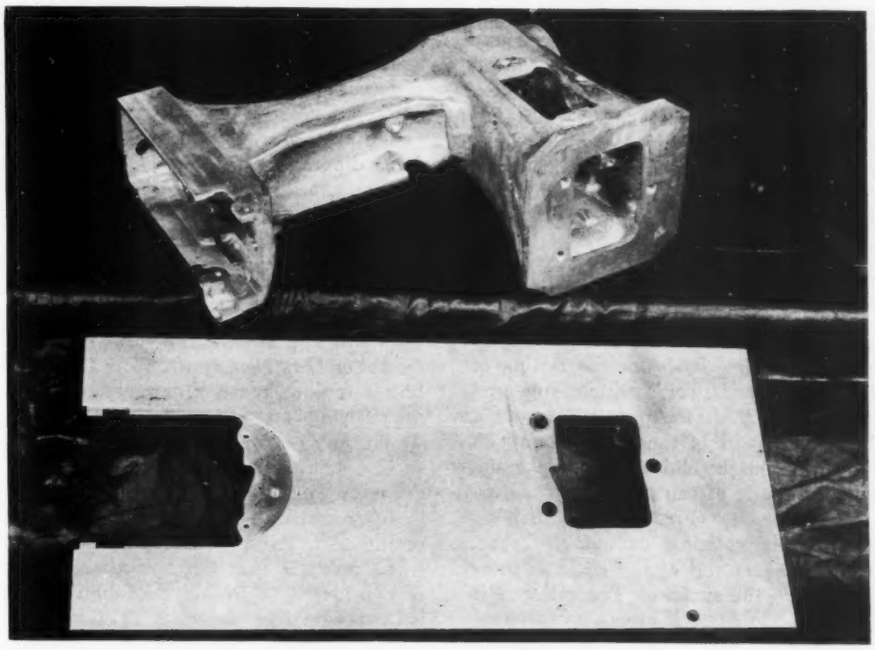
The greater coefficient of thermal expansion of magnesium makes it necessary to used slightly larger clearances for magnesium alloy. Thus in the sewing machine with the gray iron arm, about 0.002 in. clearance was allowed in the 9-in. length between the supporting bearings for end play of the upper shaft. When the arm was changed to magnesium it was found necessary to increase this end play clearance by two to three thousandths inches because with only 0.002 in. clearance, a temperature rise of only 20 deg. F. caused enough expansion to bind the shaft.

Another interesting experience was that it was found necessary to retighten some of the bolts and screws after the baking of the finish, which was at a temperature of about 300 deg. F. This loosening was also caused by the higher coefficient of expansion of the magnesium.

The finishing operations consisted of polishing the magnesium castings on a wheel, an acid dip to slightly etch the surface of the castings, and then the application of the wrinkle finish and baking. A precaution must be observed with reference to the buffing and polishing operations. They should be done on wheels that will not be used later for steel, iron or any other metal that might spark. Magnesium dust is highly explosive.

The complete White Lightweight Sewmaster includes a carrying case of compact design. The operating features of the machine include forward and reverse stitching governed by a small shift lever which independently regulates stitch length for forward and reverse sewing, numbered positive dial stitch length and tension controls, factory set and permanently pinned timing, built-in light, rocking presser foot and all the special attachments that go with the standard White sewing machine.

This new White Lightweight Sewmaster is not a mere novelty as has been evidenced by the unexpected response to its announcement. Its portability feature, without sacrifice of size, has made it appeal to not only people living in small apartments but also to women travelling in trailers or who frequently vacation from home. For many months sales have run well ahead of production schedules.



*Solely through the use of magnesium in place of cast iron for the bedplate and arm, the weight of the standard size sewing machine was reduced about 13 lb.*

# DISCUSSION OF CHAIN ACTION

## *And Effects of Centrifugal Force on Chain Load*

R. C. BINDER, *Assistant Professor;* H. A. BOLZ, *Instructor*
*School of Mechanical Engineering, Purdue University*

THE ANALYSIS of roller and silent chain drives provokes a number of fundamental questions; one is that of the distribution or transmission of forces. The article "Chain Drive Calculations" in the January number of PRODUCT ENGINEERING discussed an interesting and important point about the role of centrifugal force. The following discussion gives a detailed analysis of the forces in the links and sprocket of a roller chain drive, treating further in a somewhat different fashion the effect of centrifugal force and its distribution.

### *Forces in Links on Sprocket*

The late Prof. G. M. Bartlett, in an article, "A New Basis for the Rating of Roller Chain Drives," which appeared in *Trans. A.S.M.E.*, April, 1935, gave a short discussion of the forces acting on the links, but he did not include a detailed analysis of centrifugal force.

Referring to Fig. 1, the driving sprocket is rotating counter-clockwise. The driving strand of the chain is moving toward the sprocket. The roller *A* is just about to seat; it exerts no force on the sprocket tooth. Roller *B*, however, is completely seated; it bears on the sprocket tooth.

It is not necessary to distinguish between pin and roller links in considering the link forces. An analysis of pin bearing pressures, on the other hand, does involve a study of the differences between pin and roller links.

Consider roller *B* as a free body, first neglecting centrifugal force. The tension *T* in the chain is equal to *BM*, and the link *BC* pulls on roller *B* with a force equal to *BN*. The sprocket tooth exerts a force on the roller at the pressure angle ø. These three forces are balanced in the manner as shown in Fig. 1 by the force diagram.

Next, consider roller *C* as a free body, neglecting centrifugal force. Link *BC* pulls on roller *C* with the force *BN*. The sprocket tooth pushes on roller *C* and link *CD* pulls on roller *C*. These three forces are balanced in the force triangle shown in Fig. 2 (a). The force triangle for roller *D* is also shown. Note that the link forces decrease progressively from the driving strand to the non-driving strand. As an example, for the case shown in Fig. 1, a force analysis for each successive roller indicates that the force in link *GH* is about two per cent of the force in link *AB*. For practical purposes this small force in link *GH* sometimes may be considered negligible. Although there is a progressive decrease in the link forces, it would be impossible for the force in any link on the sprocket to become zero with a pressure angle greater than zero. With a finite pressure angle other than zero, no one of the three forces on a roller can be zero without the other two forces being zero. A zero link force, then, could result only when the driving force *T* is zero. With a zero pressure angle, however, there may be a link in which the tension reduces to zero.

If the chain speed is high enough to induce an appreciable centrifugal force, the effect may be indicated by studying further the forces acting on the rollers. Most of the mass of the chain is distributed at the roller; it seems reasonable to study the centrifugal force effect of the moving curved chain by a series of equal radial forces acting at the roller centers. Each such centrifugal force is directly proportional to the mass, directly proportional to the square of the velocity, and inversely proportional to the radius of curvature.

### *Effect of Centrifugal Force*

For the purpose of analysis, assume the same driving force *T*, and assume that a centrifugal force vector is added to each of the rollers *C*, *D*, *E*, and *F*. Figs. 2(a) and 2(b) are drawn to the same scale, the force *BN* is the same in each figure; hence a direct comparison of force vectors can be made. Comparing Figs. 2(a) ad 2(b), the effect of centrifugal force on roller *C* is to increase the tension in link *CD* and to reduce the sprocket tooth reaction. The tension in link *DE* is greater with centrifugal force than without. Continuing pro-

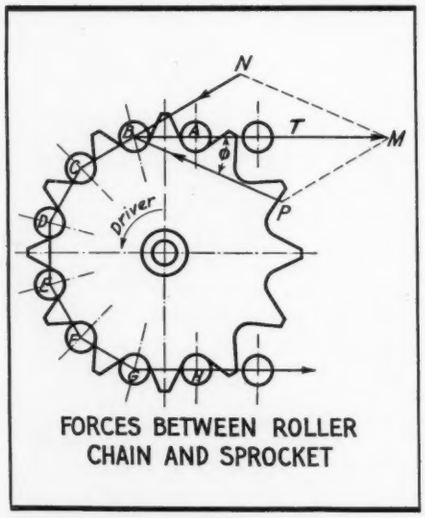



*Fig. 1—Diagram of forces between roller chain and sprocket*

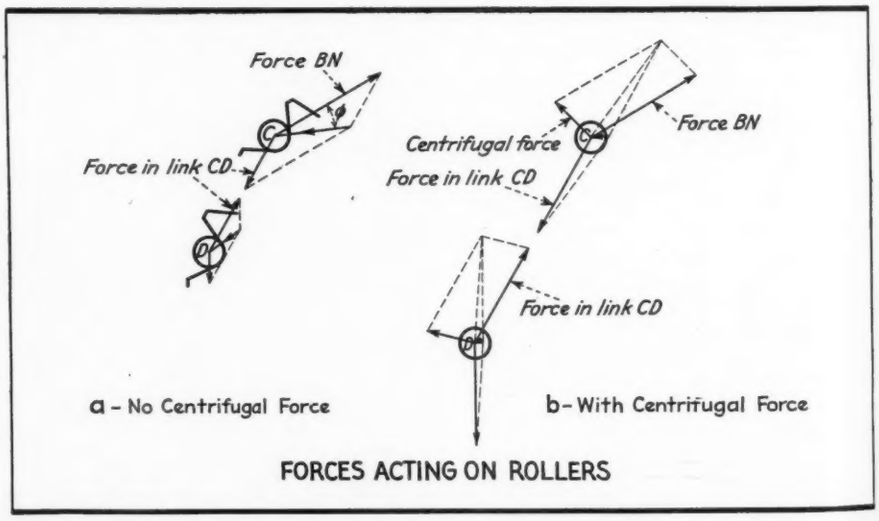



*Fig. 2—Comparison of forces acting on the rollers of a chain with no centrifugal forces present and with centrifugal forces present*

gressively, the tension in link *GH* is greater with centrifugal force than without. For the case illustrated in Figs. 1 and 2, without centrifugal force the tension in the non-driving strand is about $0.02T$; with the centrifugal force shown, the tension in the non-driving strand is about $0.37T$. These numerical values do not apply to all chain drives, these values simply provide evidence of an effect. It may be, of course, that other features in the chain drive overshadow this effect of centrifugal force. The fact remains, however, that centrifugal force does have a definite effect on the non-driving strand.

A further effect may be observed by noting the forces acting on roller *D* in Fig. 2(b). The sprocket bearing force has decreased. A roller may be reached where the sprocket force is zero, in that case the tensions are equal in the links on each side of the roller.

The above analysis is made for a system of rigid bodies, neglecting elastic deformation and elongation, and consequently assuming a constant pressure angle.

A further consideration of centrifugal force effects requires attention to chain friction, chain elongation, and to behavior of the driving and non-driving strands between the sprockets. Sometimes analogies are drawn between chain drives and belt drives. Care must be exercised in making these analogies, for there are differences between belts and chains which may affect seriously an analysis.

The following discusses one effect which is easily misunderstood unless carefully analyzed in detail.

### *Forces on Hanging Chain One Sprocket*

In Fig. 3(a) is shown diagrammatically a sprocket rotating with a hanging chain. There is a question as to whether or not the chain would fly off the sprocket as a result of centrifugal force if the speed were high enough.

The vertical force tending to lift the chain from the upper half of the sprocket is $F_c$.

Let $W$ = chain weight, lb. per ft.
$V$ = linear chain velocity, ft. per min.
$v$ = linear chain velocity, ft. per sec.
$R$ = pitch radius of upper chain loop
$g$ = 32.2 ft. per sec. per sec.

Referring to Fig. 3(b), the radial centrifugal force on a small element is

$$dF_c = \frac{WRd\theta}{g}\frac{v^2}{R}.$$

Note that the $R$'s cancel out; the centrifugal force is independent of the radius of curvature. Taking a vertical component, and integrating all such components over one half of the circle, there results

$$F_c = \int dF_c = \frac{Wv^2}{g}\int_0^{\pi} \sin\theta d\theta = \frac{2\,Wv^2}{g}$$

$$= \frac{WV^2}{57{,}960}\text{ lb.}$$

Assume that the chain has just left the sprocket, that is, the sprocket does not support any vertical load. $F_c$ acts vertically upwards on the chain. The chain weight acts vertically downward and is equal to $WL$, where $L$ is the length of the chain.

Furthermore, the lower loop of the chain gives rise to a resultant centrifugal force component $F_D$ acting vertically downward; the lower loop may have a smaller radius of curvature than that over the pulley. The hanging portion of the chain is a catenary. Rigorous computations could be made for this catenary, but such computations would be open to question because of the kinking effects due to unflexing of the chain where the chain leaves the sprocket and where the chain moves from the lower loop up to the sprocket.

At any rate, it seems difficult to conceive of $F_D$, as illustrated in Fig. 3(c), as being small in comparison with $F_c$; $F_D$ is probably of the same order of magnitude as $F_c$. But to enable the chain to leave the sprocket, $F_c$ must be greater than the sum $(WL + F_D)$. Consequently, it is highly improbable that the chain will be thrown from the sprocket at high speeds as a result of centrifugal force action alone.

Further, it is of interest to note that the above effect is independent of the weight of chain per foot. The force $F_D$ is of the same character as $F_c$. The linear velocity is the same, the only difference being in the geometrical configuration. $F_D$ can then be written as $F_D = KF_c$, where $K$ is some non-dimensional coefficient of the order of magnitude of one. Then, if the chain is to leave the sprocket

$$F_c > F_D + WL > KF_c + WL$$

$$F_c > \frac{WL}{1-K}$$

$$\frac{WV^2}{57{,}960} > \frac{WL}{1-K}$$

Inspection of the last relation shows that the weight $W$ cancels out and the effect is independent of $W$, the weight per foot of chain.

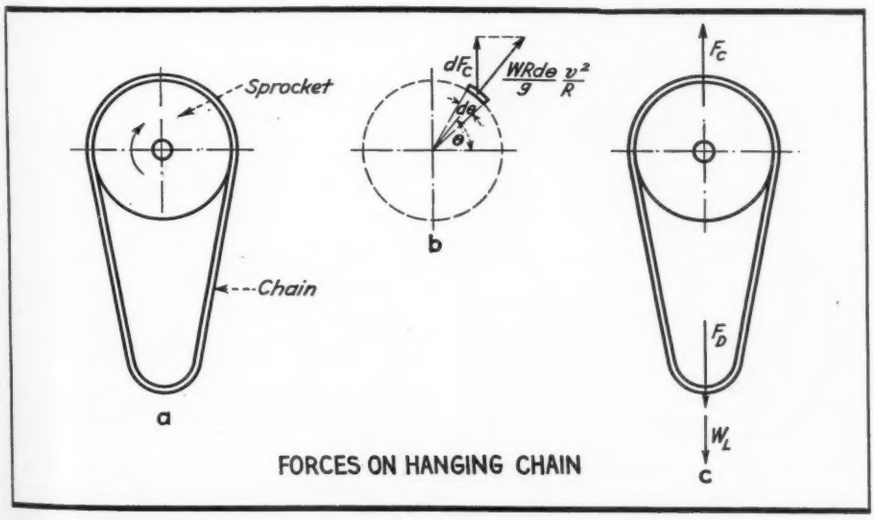
### *Other Factors to Consider*

This discussion may be questioned on the basis of experience with belts. A clear space between belt and pulley on the driven pulley of a high speed belt drive may be observed. This space is due to belt stretch.

One must be careful to avoid confusing centrifugal force with some other inertia force. If a belt is suddenly placed on a high speed pulley, the belt may be thrown from the pulley. This is due to a sudden impulse being given to the belt, somewhat different from a centrifugal force action. The belt may leave the pulley; after losing its momentum it will drop back on the pulley. A series of movements on and off the pulley may result. Care must be exercised in distinguishing this action from a centrifugal force action. If a sprocket is brought up to speed gradually, and if the elastic stretch is negligible, there is a very grave doubt that the chain would ever be thrown from the sprocket by centrifugal force action alone.

The authors are grateful to Professor E. S. Ault, head of the machine design department at Purdue University, for help in making this study.

*(Continued on next page)*




FORCES ON HANGING CHAIN

*Fig. 3—Forces acting on a running chain suspended from its sprocket and the lower loop entirely free of restraint*

## *Discussion of Chain Action (Continued)*

***Comments by the Editor***

The above discussion of chain action by Professor Binder and Mr. Bolz is an excellent analysis of the forces acting on a chain running around a sprocket. But as they point out in their discussion, "It may be, of course, that other features in the chain drive overshadow this effect of centrifugal force. . . . The above analysis is made for a system of rigid bodies, neglecting elastic deformation and consequently assuming a constant pressure angle."

In standard roller chains the clearance between the pins and bushings ranges from 0.001 in. for a ⅜-in. pitch chain to 0.002 in. for a 1-in. pitch chain when new. Offsetting possible effect of this, minus tolerance is specified for the bottom diameters of cut sprockets, the positive tolerance of which being zero.

It is possible that when the chain links seat in the sprocket the side plates are put under tension. Only under such a condition could the link *BC* exert a pull on the roller *B*. But the amount of elongation or elastic deformation in the side plates in order to exert a force such as *BN*, is extremely small. Assuming that the plates are stressed to 15,000 lb. per sq.in., for an elastic modulus of 30,000,000 the elongation for a pitch of 1 in. would be only of the order of 0.0005 in. Because the dimensional quantities involved are so small, and considering the wear that takes place on both the chain and the sprocket teeth, it is hard to conceive how the distribution of forces in a running chain would be comparable to that obtained by an analysis based on rigid bodies with no clearances or elongations in the chain.

However, in discussing the above analysis with Mr. N. C. Bremer, chief engineer of Morse Chain Company, whose discussion is given below, he stated that he cannot agree with my deductions, and I must confess that Mr. Bremer's far greater experience lends a correspondingly greater value to his opinions. A definite and conclusive answer to this whole problem could be obtained by making a full scale model of a chain and sprocket rim out of photoelastic material and observing the action while running by means of a stroboscope. This would clearly indicate the distribution of load over the numbers of teeth and might also indicate the action of centrifugal force.

With reference to the action of centrifugal force tending to lift the chain off the sprocket, as the authors point out, "the centrifugal force is independent of the radius of curvature." Hence $F_c$ must equal $F_D$, which also proves their conclusion. Mr. Bremer's experiments as shown below bear this out beautifully, and also confirm the conclusions expressed by Professor Binder and Mr. Bolz in the next to last paragraph of their discussion.

## *Experiments Confirm Analysis*

**N. C. BREMER,** ***Morse Chain Company***

The discussion by R. C. Binder and H. A. Bolz seems to me to hit the nail squarely on the head. It confirms practically everything that was stated in the article. The omission of any mention of the effect of centrifugal force on the driving strand bears out our contention that centrifugal force should not be considered at all in the load calculations.

As to effect of centrifugal force on the non-driving strand, we made no mention of this because with the silent chain design we are able to eliminate most of this effect. Furthermore, a certain amount of centrifugal tension in the non-driving strand serves to prevent shock-loading, in that the tension in the whole chain varies from a maximum to a minimum but never reaches zero.

The action of centrifugal force is to transfer the working load to the "leaving" end of the driving sprocket and to the "entering"side of the driven sprocket. There can be a distribution of load over a great number of sprocket teeth, even though considerable pitch elongation has developed.

I sincerely hope that you will materially endorse Prof. Binder's paper because it seems to me that his analysis, in a technical manner, substantiates our more or less practical deductions.

An experiment which will prove our contentions that the sprocket does absorb most of the centrifugal tension is as follows:

In Fig. 5 of the article "Chain Calculations" which appeared in the January number of PRODUCT ENGINEERING we showed a chain draped around a sprocket and rotating so that the chain was given a linear velocity of 5,000 ft. per min. Much speculation has arisen as to just what would happen to the chain were it not for the sprocket teeth. To clear up any doubt about this subject I arranged an exhibit which turned out to be most interesting. We managed to get a loop of chain spinning at 5,000 ft. per min. on a wheel which had no teeth. Fig. 1 shows the result of this clearly.

It will be noticed that the loop of chain describes an almost perfect circle.

On the other hand, Fig. 2 shows the same chain running at the same speed over a sprocket, and illustrates the restraining effect of the sprocket teeth. No additional tension is necessary to maintain traction; a working tension may be entirely substituted for centrifugal tension in the straight strand.

To get sufficient traction to overcome the fan effect of the chain shown by Fig. 1, it was necessary to use a V-shaped pulley which engaged the sides of the chain. High sides were necessary to prevent the chain from jumping out while coming up to speed. The effective radius of pulley and sprocket are the same.

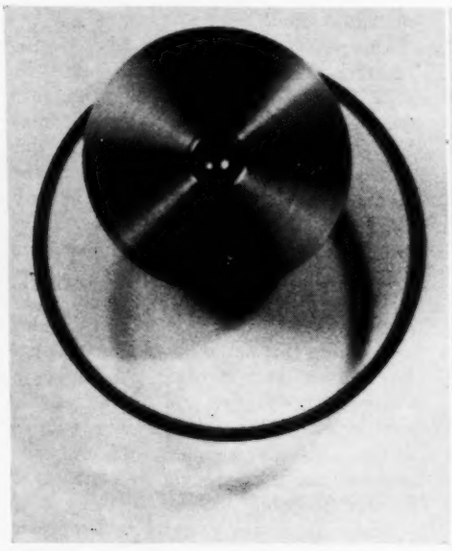


*Fig. 1—A chain on a toothless wheel spinning at 5,000 ft. per minute takes the form of a circle because of centrifugal force*

*Fig. 2—The same chain running on a standard sprocket at 5,000 ft. per min. is constrained to a non-circular path*

# RIGID FRAMES

## *Detailed Procedure for Stress Calculations*

O. F. KENDLER

OF THE TWO METHODS for calculating stresses in rigid frames —the theorem of least work and the grapho-analytical method, the latter is the simpler. The fundamental equations involved in each of these methods are set forth in advanced textbooks such as Timoshenko's "Strength of Materials" (D. Van Nostrand Company) and others. To clarify the procedure in the application of the equations, a step by step solution of a typical practical problem solved by the simpler grapho-analytical method is given here. A truck side frame has been selected for the illustrative example but the method is equally applicable to any similar framed structure.

The basic equations in the grapho-analytical method are derived from the fact that the angle of rotation of the ends of a simply supported beam is equal to the reactions at the supports caused by an imaginary loading, divided by the flexural rigidity, $EI$, of the beam. The imaginary loading must be such as would be represented by the bending moment diagram. Fig. 1 illustrates this. The bending moment diagram for a simple beam is a triangle. Maximum moment is at the center of the beam and is equal to $PL/4$. Calling the area of this bending moment diagram the imaginary load, we find that the total (area) load is equal $PL/4 \times L/2 = PL^2/8$ and hence the reaction of each support will be equal to $PL^2/8 \times 2$ or $PL^2/16$.

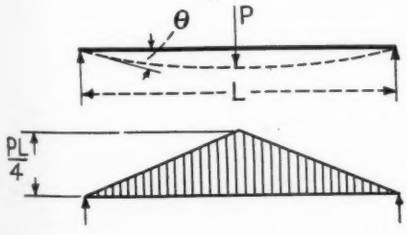



*Fig. 1—The angle of rotation at the supports of a simple beam is equal to the reaction that would be obtained if the beam were given an imaginary loading that could be represented by the bending moment diagram divided by* EI *of beam*

As explained in Timoshenko's "Strength of Materials," Part I, page 159 (Equation (123) with $c$ made equal to $L/2$) the angle of rotation of the end of the beam will be

$$\theta = \frac{PL^2}{16\,EI}$$

Applying this theory to a loaded frame such as shown in Fig. 2, we have the condition that because of the rigid joints the angles of rotation at any corner must

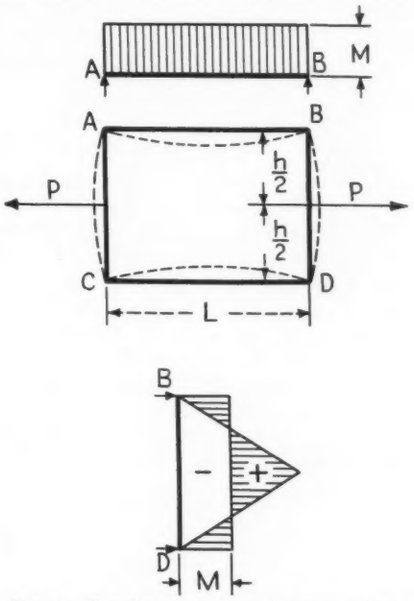



*Fig. 2—Bending moment diagrams for a rigid frame subjected to the concentrated loads* P *acting at the mid points of opposite sides*

be equal for both of the members that form the corner. Thus, in Fig. 3 the angle of rotation of member $AB$ at $B$ must be equal to the angle of rotation of member $DB$ at $B$. Therefore, in the solution of the problem we can assume that the frame has been cut at the corners and each of the members is subjected to couples $M$ as shown, the members $AB$ and $BD$ behaving as simply supported beams.

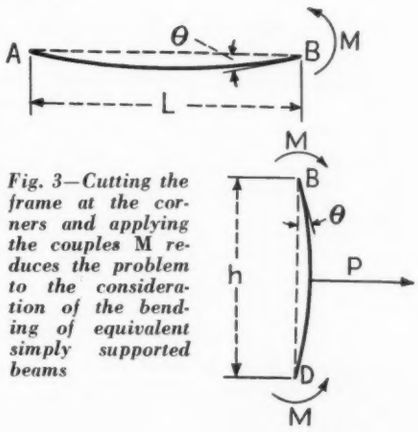



*Fig. 3—Cutting the frame at the corners and applying the couples* M *reduces the problem to the consideration of the bending of equivalent simply supported beams*

Thus, the angle of rotation $\theta$ of the end of the bar $BD$, as caused by the load $P$, is

$$\theta = \frac{Ph^2}{16\,EI}$$

The couple $M$, turning the bar $BD$ in the opposite direction, reduces this angle by

$$\frac{Mh}{2\,EI}$$

The angle produced by $M$ at the ends of the bar $AB$ equals

$$\frac{ML}{2\,EI_1}$$

and due to rigid frame corners

$$\frac{ML}{2\,EI_1} = \frac{Ph^2}{16\,EI} - \frac{Mh}{2\,EI}$$

Solving for $M$, we get

$$M = \frac{Ph}{8}\left(\frac{1}{1 + LI/hI_1}\right)$$

This is the fundamental equation by which the moments can be calculated. The procedure will be illustrated by its application to the calculation of the bending moments in cast steel truck side frames for railroad cars. In general the procedure will be the same when analyzing any rigid frame such as in airplanes, truck bodies or machine frames.

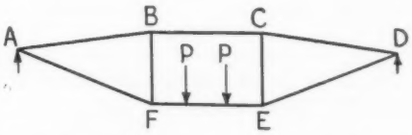



*Fig. 4—Rigid frame subjected to loads* P *and* P *and supported at its end*

The outline of the truck frame subjected to two vertical loads, $P$ and $P$ is shown in Fig. 4. By cutting the frame at the corners $BCEF$ and applying couples $M$ and $M_1$, Fig. 5, the problem will be reduced to the consideration of bending of the bars $FE$, $BF$ and $BC$. The stiffening effect of bars $AB$, $AF$ and $DC$, $DE$, Fig. 4, on the frame $BCEF$, should be accounted for by increasing the moment of inertia of $BF$ by adding to it the average moment of inertia of $AB$ and $AF$ decreased in proportion to the length of the bar $BF$ to the total length of the bar $AB$ plus the length of the bar $AF$. Although this method of correcting for the stiffening effect of the bars $AB$ and $AF$ is not absolutely accurate, the inaccuracy

will be negligible. Expressed as an equation, we have

$$I \text{ of } BF = I_1 \frac{BF}{AB + AF} + I_2 \qquad (1)$$

$I$ = Increased moment of inertia of $BF$
$I_1$ = Average moment of inertia of $AB$ and $AF$
$I_2$ = Actual average moment of inertia of $BF$

Let
$I_3$ denote the average moment of inertia of $BC$
$I_4$ denote the average moment of inertia of $FE$

We can now write the equations wherein the letters $a$, $b$, $c$, $d$ and $e$ refer to the dimensional quantities shown in Fig. 5.

$$\frac{Pd}{2\,I_4E}(d+e) - \frac{Ma}{2\,I_4E} = \frac{Mb}{3\,IE} - \frac{M_1b}{6\,IE} \qquad (2)$$

$$\frac{Mb}{6\,IE} - \frac{M_1b}{3\,IE} = \frac{M_1a}{2\,I_3E} \qquad (3)$$

from which $M$ and $M_1$ can be determined.

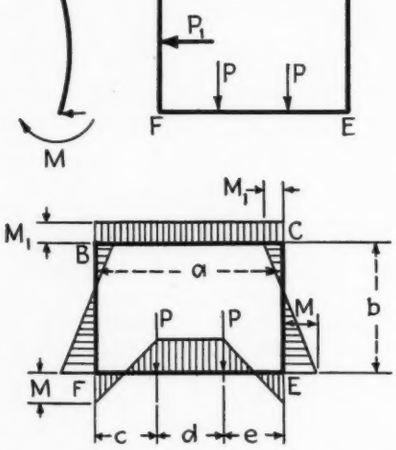



*Fig. 5—Imaginary loading diagram for the middle section of the truck side frame*

Considering an additional load $P_1$, acting at the center of the bar $BF$, Fig. 5, we get the general equations

$$\frac{Pd}{2\,I_4E}(d+c) - \frac{Ma}{2\,I_4E} = \frac{Mb}{3\,IE} - \frac{M_1b}{6\,IE} - \frac{P_1b^2}{16\,IE} \qquad (4a)$$

$$\frac{Mb}{6\,IE} - \frac{M_1b}{3\,IE} - \frac{P_1b^2}{16\,IE} = \frac{M_1a}{2\,I_3E} \qquad (4b)$$

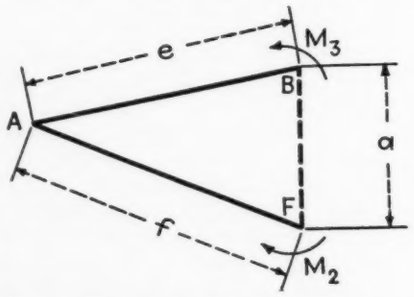



*Fig. 6—End section of the frame shown in Fig. 4*

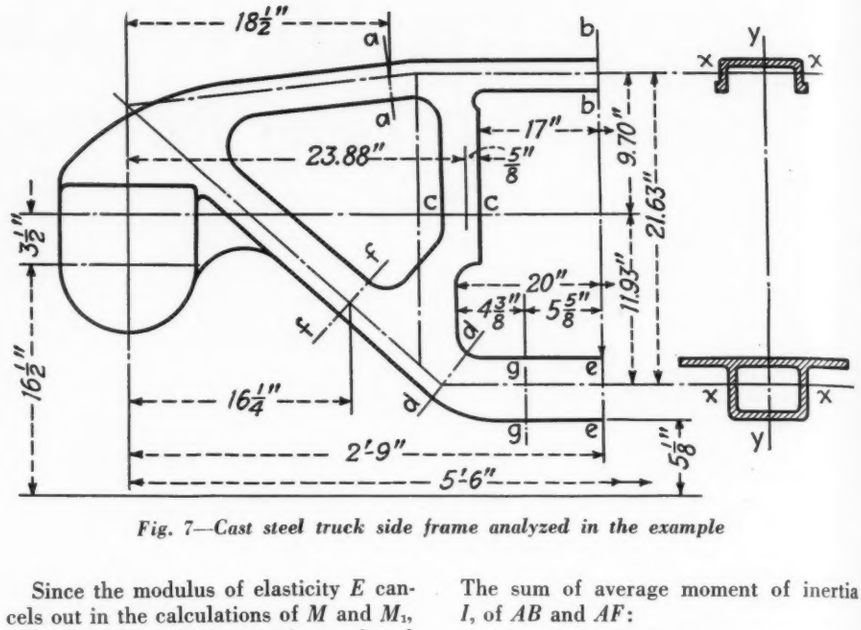



*Fig. 7—Cast steel truck side frame analyzed in the example*

Since the modulus of elasticity $E$ cancels out in the calculations of $M$ and $M_1$, a value of $E$ = unity may be used and the work shortened. The last four of the above equations are good for the loading as shown in Fig. 4. For a different kind of loading, the first member of these equations should be changed accordingly.

The couples $M_2$ and $M_3$, Fig. 6, acting on bars $AF$ and $AB$, of the triangular part of the frame are equal to

$$M_2 = M \frac{I_1 \dfrac{a}{e+f}}{I_2 + \dfrac{I_1 a}{e+f}} \qquad (5)$$

and

$$M_3 = M_1 \frac{I_1 \dfrac{a}{e+f}}{I_2 + \dfrac{I_1 a}{e+f}} \qquad (6)$$

where $I_1$ denotes the actual average moment of inertia of $AB$ and $AF$, and $I_2$ the actual average moment of inertia of $BF$.

A numerical example will be given to illustrate the step by step and procedure in greater detail.

### *Properties of Frame Section Shown in Fig. 7*

| Sec. | $M\,I_{x-x}$ | $S\,M_{x-x}$ | $M\,I_{y-y}$ | $S\,M_{y-y}$ | Area |
|---|---|---|---|---|---|
| a–a | 3.11 | 1.88 | 19.69 | 6.84 | 5.14 |
| b–b | 6.51 | 3.57 | 32.08 | 9.88 | 6.53 |
| c–c | 2.40 | 1.55 | 29.48 | 9.10 | 6.04 |
| d–d | 18.37 | 9.00 | 64.73 | 12.95 | 10.53 |
| e–e | 44.69 | 15.15 | 103.65 | 17.28 | 12.90 |
| f–f | 6.60 | 3.17 | 24.93 | 8.65 | 6.02 |
| g–g | .... | 15.15 | .... | .... | .... |

Length of members $BF$ = 20.00 in. (Fig. 8)
Length of members $AB$ = 20.63 in.
Length of members $AF$ = 26.25 in.

The sum of average moment of inertia $I$, of $AB$ and $AF$:

$$I_1 = \frac{3.11 + 6.60}{2} = 4.86 \text{ in.}^4$$

The increased average moment of inertia of $BF$, according to Equation (1) is

$$I = 2.40 + \frac{4.86 \times 20}{20.63 + 26.25} = 4.48 \text{ in.}^4$$

Changing Equations (2) and (3) for 3 $P$ loads and solving for $M$ and $M_1$, we obtain

$$M_1 = \frac{\dfrac{Pd\,(d+c)}{2\,I_4} + \dfrac{Pa^2}{16\,I_4}}{\dfrac{a}{I_3} + \dfrac{b}{2\,I} + \dfrac{3\,I\,a^2}{2\,I_3\,I_4\,b} + \dfrac{a}{I_4}} \qquad (7)$$

and

$$M = M_1\left(\frac{3\,I\,a}{I_3 b} + 2\right) \qquad (8)$$

where, as shown in Fig. 8,

$P$ = 16,000 lb.
$c$ = 4.375 in.
$d$ = 11.26 in.
$b$ = $a$ = 20 in.
$I_4$ = 31.53 in.$^4$
$I_3$ = 6.51 in.$^4$
$I$ = 4.48 in.$^4$

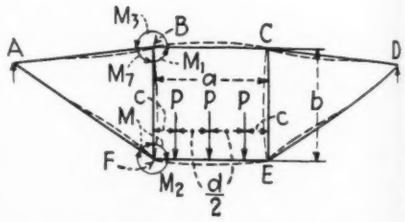



*Fig. 8—Outline of frame subjected to three equal vertical loads*

Substituting these values in Equations (7) and (8)

$M_1$ = + 4,600 lb.-in.
$M$ = − 20,066 lb.-in.

and from Equations (5) and (6)

$M_2$ = − 10,863 lb.-in.
$M_3$ = + 1,664 lb.-in.

### *Calculation of Bending Stresses from 3P Loads*
### *Bending Stresses in EF, Fig. 9*

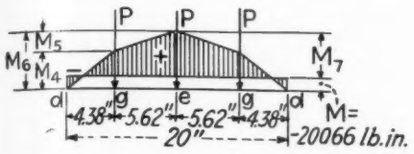



*Fig. 9—Imaginary loading diagram for the bottom chord* EF *of the truck side frame*

$P$ = 16,000 lb. $M$ = 20,066 lb.-in.

Reactions $E = F = \frac{16{,}000 \times 3}{2} = 24{,}000$ lb.

$M_4 = 24{,}000 \times 4.38 = 105{,}100$ lb.-in.
$M_6 = 24{,}000 \times 10 - 16{,}000 \times 5.62 = 150{,}080$ lb.-in.
$M_7 = M_6 - M = 130{,}014$ lb.-in.
$M_5 = M_4 - M = 85{,}934$ lb.-in.

Maximum bending stress

Sec. $d$–$d$ $\frac{M}{W_{d-d}} = -\frac{20{,}066}{9.00} = -2{,}230$ lb. per sq.in.

Sec. $g$–$g$ $\frac{M_5}{W_{g-g}} = \frac{85{,}034}{15.15} = 5{,}615$ lb. per sq.in.

Sec. $e$–$e$ $\frac{M'}{W_{e-e}} = \frac{130{,}014}{15.15} = 8{,}600$ lb. per sq.in.

$W_{d-d}$, $W_{g-g}$ and $W_{e-e}$ being the moments of resistance of sections $d$–$d$, $g$–$g$ and $e$–$e$ respectively.

### *Maximum Bending Stresses in BF, Fig. 10*

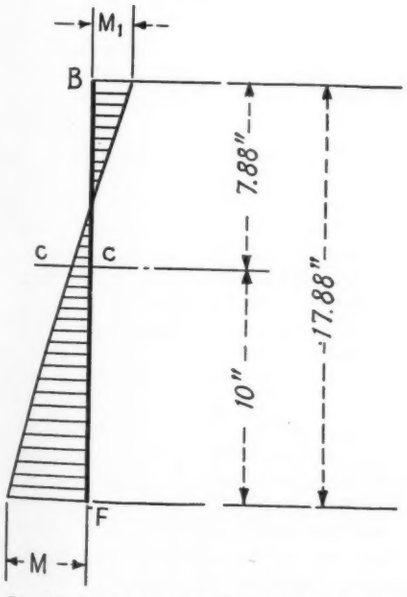



*Fig. 10—Imaginary loading diagram for* BF

$M$ = − 20,066 lb.-in.
$M_1$ = 4,600 lb.-in.

$M$ at Sec. $c$–$c$ $= \frac{M \times 7.88}{17.88} - \frac{M_1 \times 10}{17.88}$

$= -6{,}232$ lb.-in.

Maximum bending stresses at sec. $c$–$c$

$\frac{M_7}{W_{c-c}} = -\frac{6{,}232}{1.55} = -4{,}020$ lb. per sq.in.

### *Maximum Bending Stresses in BC, Fig. 11*

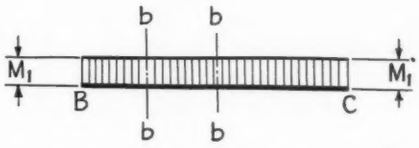



*Fig. 11—Imaginary loading diagram for* BC

$M_1$ = 4,660 lb.-in.

Maximum bending stress at any sec. $b$–$b$

$\frac{M_1}{W_{b-b}} = \frac{4{,}660}{3.57} = 1{,}305$ lb. per sq.in.

### *Maximum Bending Stresses in AF, Fig. 12*

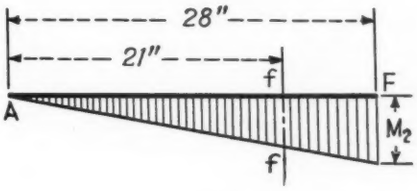



*Fig. 12—Imaginary loading diagram for* AF

$M_2$ = − 10,863 lb.-in.

$M_{f-f} = -\frac{10{,}863 \times 2}{28} = -8{,}127$ lb.-in.

Maximum bending stress at sec. $f$–$f$

$\frac{M_{f-f}}{W_{f-f}} = -\frac{8{,}127}{3.17} = -2{,}564$ lb. per sq.in.

### *Maximum Bending Stress in AB, Fig. 13*

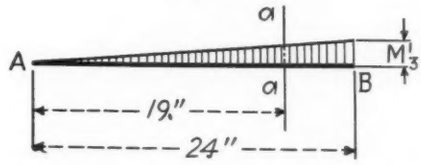



*Fig. 13—Imaginary loading diagram for* AB

$M'_3$ = 1,664 lb.-in.

$M_{a-a} = \frac{1{,}664 \times 19}{24} = 1{,}320$ lb.-in.

Maximum bending stress at sec. $a$–$a$

$\frac{M_{a-a}}{W_{a-a}} = \frac{1{,}320}{1.88} = 710$ lb. per sq.in.

### *Calculation of Bending Moments from Three Vertical Loads and Horizontal Load $P_1$ Acting on BF or CE, Fig. 14*

$P$ = 16,000 lb.
$P_1$ = Bolster reaction, according to ARA manual = 7,750 lb. for 40 ton truck side frames.

Changing equations (4a) and (4b) for 3 loads and equal to $P$ and solving for

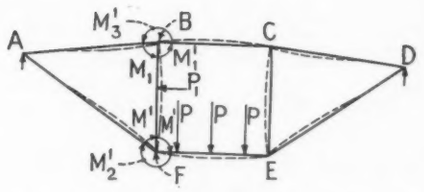



*Fig. 14—Frame subjected to three vertical loads and a horizontal load acting on* BF *or* CE

$M'$ and $M_1'$ we obtain

$$M'_1 = \frac{\frac{Pd}{2I_4}(d+e) + \frac{3P_1ab}{16I_4} + \frac{3P_1b^2}{16I}}{\frac{a}{2I_3} + \frac{b}{2I} + \frac{3a^2I}{4I_4I_3b} + \frac{n}{I_4}}$$

$$M' = M'_1\left(\frac{3aI}{2I_3b} + 2\right) - \frac{3P_1b}{8}$$

Notations are as given in calculation of couples from 3 vertical loads.
From which

$M'_1$ = + 3,340 lb.-in.
$M'$ = − 37,937 lb.-in.

From Equations (5) and (6)

Couple $M'_2$ = − 20,487 lb.-in.
and $M'_3$ = + 1,193 lb.-in.

### *Bending Stresses from 3 Vertical P Loads and Horizontal $P_1$ Load Maximum Bending Stresses in EF, Fig. 15*

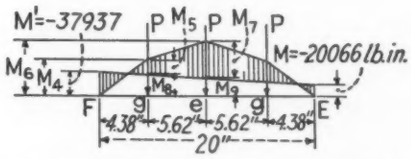



*Fig. 15—Imaginary loading diagram for the member* EF *subjected to three vertical loads*

$P$ = 16,000 lb.
$M$ = − 20,066 lb.-in.
$M'$ = − 37,937 lb.-in.

Reactions from 3 $P$ loads

$E = F = \frac{16{,}000 \times 3}{2} = 24{,}000$ lb.

$M_4 = 24{,}000 \times 4.38 = 105{,}100$ lb.-in.

$M_5 = M_4 - M_8 = 105{,}100 - \left(20{,}066 + \frac{(37{,}937 - 20{,}066)\,15.62}{20}\right)$

$= 71{,}078$ lb.-in.

$M_6 = 24{,}000 \times 10 - 16{,}000 \times 5.62 = 150{,}080$ lb.-in.

$M = M_6 - M_9 = 150{,}080 - \left(20{,}066 + \frac{(37{,}937 - 20{,}066) \times 10}{20}\right)$

$= 120{,}979$ lb.-in.

Maximum bending stresses

Sec. $d$–$d$ $-\frac{37{,}937}{9.00} = -4{,}216$ lb. per sq.in.

*(Continued on next page)*

Sec. $g-g$ $\quad \frac{71,987}{15.15} = \quad 4,730$ lb. per sq.in.

Sec. $c-c$ $\quad \frac{120,979}{15.15} = \quad 7,960$ lb. per sq.in.

### *Maximum Bending Stress in BF, Fig. 16*

$M'_1 = +3,340$ lb.-in.
$M' = -37,938$ lb.-in.
$P_1 = 7,750$ lb.

$$M_p = -\frac{7,750}{2} \times 8.94 = 34,643 \text{ lb.-in.}$$

$$M_{c-c} = M_p - M_1 + M'_1 = \frac{34,643 \times 7.88}{8.94} - \frac{37,938 \times 7.85}{17.88} + \frac{3,340 \times 10}{17.88}$$

$$= 15,700 \text{ lb-in.}$$

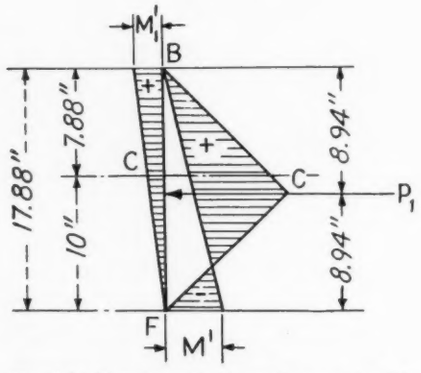



*Fig. 16—Imaginary loading diagram for* BF

Maximum bending stress in sec. $c-c$

$$\frac{M_{c-c}}{W_{c-c}} = \frac{15,700}{1.55} = 10,120 \text{ lb. per sq.in.}$$

### *Maximum Bending Stress in BC, Fig. 17*




*Fig. 17—Imaginary loading diagram for* BC

$M' = 4,660$ lb.-in.
$M'_1 = 3,340$ lb.-in.

Maximum bending stress at corner $C$

$$\frac{M_1}{W_{c-c}} = \frac{4,660}{3.57} = 1,305 \text{ lb. per sq.in.}$$

### *Maximum Bending Stress in AF, Fig. 18*

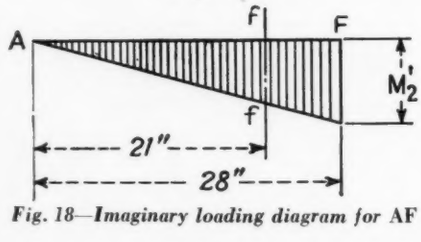



*Fig. 18—Imaginary loading diagram for* AF

$M'_2 = 20,487$ lb.-in.

$$\frac{M_{f-f}}{W_{f-f}} = -\frac{15,400}{3.17} = -4,850 \text{ lb. per sq.in.}$$

### *Maximum Bending Stress in AB, Fig. 19*

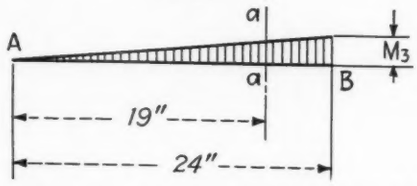



*Fig. 19—Imaginary loading diagram for* AB

$M'_3 = 1,192$ lb.-in.

$$M_{a-a} = \frac{1,192 \times 19}{24} = 945 \text{ lb.-in.}$$

Maximum bending stress at sec. $a-a$

$$\frac{M_{a-a}}{W_{a-a}} = \frac{945}{1.88} = 505 \text{ lb. per sq.in.}$$

From Tables I and II we notice that a horizontal load $P_1$ acting on BF increases the bending stresses at section $c-c$ and section $d-d$, and at section $a-a$, $e-e$ and $g-g$ the addition of the horizontal load reduces the stresses.

The same general procedure as detailed above can be applied to the stress analysis of any rigid frame subjected to any number of vertical and horizontal loads. It is of interest that an analysis such as above when checked against test results, showed an agreement within 10 per cent. This slight difference can readily be accounted for by irregularities in thicknesses of the cast sections.

**Table I — Maximum Bending Stresses from Vertical Loads**

| Section | Stress in lb. per sq. in. |
|---|---|
| $a-a$ | 710 |
| $b-b$ | 1,305 |
| $c-c$ | —4,020 |
| $d-d$ | —2,230 |
| $e-e$ | 8,600 |
| $f-f$ | —2,564 |
| $g-g$ | 5,615 |

**Table II — Maximum Bending Stresses from Combined Vertical and Horizontal Loads**

| Section | Stress in lb. per sq. in. |
|---|---|
| $a-a$ | 505 |
| $b-b$ | 1,305 |
| $c-c$ | 10,120 |
| $d-d$ | —4,216 |
| $e-e$ | 7,960 |
| $f-f$ | —4,850 |
| $g-g$ | 4,730 |

## *Clues from Crystals*

AT ABSOLUTE ZERO, 460 deg. below Fahrenheit zero, theoretically all gases would become solid, all molecular motion would cease, and the atoms of metals after an extremely long time would align themselves in orderly array.

In studying the elastic and electrical properties of metals, Dr. Sidney Siegel, of the Westinghouse Research Laboratories, recently has simulated one of the effects of absolute zero by "growing" single crystals of a mixture of copper and gold, in which the atoms are arranged in definite order. Such crystals, which have an electrical conductivity about twice as great as that of disordered crystals, are produced by an unusual method of heat-treatment in a vacuum furnace.

A crucible containing a mixture of about three atoms of copper to one atom of gold is lowered by a tungsten wire inside an alundum tube. The tube is surrounded by a coil of molybdenum wire, which is heated by direct current, and the entire unit is inclosed in a highly evacuated chamber. In approximately 4 hours the metal is melted and solidified at a temperature of about 2,000 deg. At this point the temperature is lowered about 500 deg. and during the next 12 hours the crystal is allowed to cool to room temperature. If the crystal were cooled rapidly, the atoms would arrange themselves in a disorderly manner. Dr. Siegel prevents this erratic formation by lowering the crucible slowly into the cooling chamber of the furnace in such a way that each plane of atoms is cooled successively under the same conditions. The resulting crystal is $\frac{3}{16}$ in. in diam. and varies in length from an inch or so to 4 in., depending upon the amount of material placed in the crucible.

At room temperature, Dr. Siegel estimates, 90 per cent of the atoms are arranged neatly in alternate rows of copper and gold, but this order decreases as temperature is increased, and at 716 deg. it disappears completely.

Study of the electrical and elastic properties of these crystals may clarify the fundamental nature of interatomic forces that determine the properties of structural materials. Dr. Siegel believes that a workable theory of the "order-disorder" arrangement of atoms would help metallurgists to substitute exact knowledge for the usual trial-and-error methods of combining metals to produce alloys, for in principle all the properties of a metal should be calculable if only the position of its atoms and the forces acting between them were known.

# PROPOSED PATENT LAWS

KARL FENNING
*Patent Lawyer, Washington, D. C.*

IN the February number of PRODUCT ENGINEERING certain restrictions proposed by the Department of Justice on the right of an inventor to deal with his patent were considered.

It is far from certain that any of these restrictions are needed. The testimony introduced by the Department of Justice before the Temporary National Economic Committee when fairly read seemed not to indicate material abuses of the patent system in the respects involved in the amendments proposed by the Department of Justice. In this connection it is to be noted that Senator King, a member of the Temporary National Economic Committee, has issued a statement indicating that he is unable to satisfy himself that these proposals of the Deparment of Justice should be enacted into law.

What may be intended by the Department of Justice as a saving clause seems merely to throw uncertainty and hazard into the situation as a detriment to inciting to invention. It is proposed that in addition to the specific inhibitions it should be provided that if a license is granted it must be general and unrestricted unless the patentee is prepared to demonstrate that a particular restriction, other than those already considered, is necessary to promote science and useful arts.

This seems to indicate that the Department of Justice has listed the restrictions which it believes are harmful and then suggests that if anybody thinks of any other restrictions they shall also be held harmful unless the patentee can show that they are essential to promote science and useful arts. This means that anyone who includes a restriction in a license is presumed guilty unless he proves that he is innocent. He is given no criterion by which he can make such proof and he must go ahead entirely at his own hazard. Such uncertainty will not tend to induce one to seek a patent since by so doing he may merely be sticking his head into a noose by issuing a license, without any hint as to when or how or by whom the rope may be pulled.

The Department of Justice also suggests that "it should be made unlawful for any person to whom a patent has been issued or who has in any other way acquired any patent or any interest in or right or license under a patent, to sell, lease, or otherwise dispose of any article produced or sold under such patent or any such right or license on any restriction condition of the kind" which cannot be inserted in a license under the patent itself; that is, as to price, production, use, or geographical area. This restriction is no more necessary than, and in some respects may be as harmful as, the license restrictions proposed by the Department of Justice.

In this connection it is interesting to note that there have recently been enacted in a number of States so-called "fair trade laws" which make it possible for a manufacturer who puts out goods under a trade mark to specify the price at which the goods shall be sold. These laws have been sustained by the Supreme Court. It will be remembered that goods manufactured under a trade mark need not be new, and may be goods already in ordinary commerce. It is surprising, therefore, to find the Department of Justice suggesting that it is improper to place similar restrictions on a patented article which is new and is introduced to the public only by way of the patent, especially when the restrictions can last only for the seventeen years of the life of the patent. Trade marks may last not for a limited period but for as long as a man continues in business. In some instances already trade mark owners have had a monopoly of their marks for over a century. Apparently even if it bears a trade mark the price of a patented device would not be allowed to be fixed.

### *Restrictions On Use*

The restriction or limitation on use seems generally to be acknowledged as economically right. The courts have recently sustained such limitations on copyrighted matter. Thus it is possible for one to sell a phonograph record containing copyrighted music and put on it a license precluding its use for broadcasting or precluding its use in a public place of amusement. Such restrictions are enforced by the courts and the bills in Congress rewriting the copyright law contain specific provision for such limited licenses of use of reproductions of copyrighted matter. There seems to be every reason for allowing the owner of a patent as much freedom in dealing with the patented device as is allowed the owner of a copyright in dealing with a copyrighted device. There seems to be little public support for this particular proposal of the Department of Justice.

The Department of Justice also proposes to require all assignments and licenses under patents to be filed with the Federal Trade Commission and to be open to Government inspection. It might be better to have all evidence of title in the Patent Office. Terms of licenses may be confidential and probably should not be made open to the public but it might be well, on the other hand, to give the public merely notice that there is a license or assignment of some sort so that a purchaser of a patent can know whether he can get a clear title.

The Department of Justice would also prohibit a suit against a user or seller before suing the maker of an infringing device, saying such suits are sometimes brought only to destroy competition. Such a provision would have to be worked out in careful detail to avoid doing more harm than good.

It may be admitted that sometimes suits are brought against shippers or dealers in order to scare them away from purchasing goods from a manufacturer. This procedure may be a more direct way of compelling a manufacturer to cease infringing a patent. Of course it is possible for the manufacturer to agree to defend suits brought against dealers and to pay any damages recovered. The Department of Justice seems to think this is an unreasonable procedure and wishes to relegate the patentee to a suit against the manufacturer. It may be, however, that a manufacturer does not mark his goods, so that it may be very difficult if not substantially impossible for a patentee to learn who is the actual manufacturer. The only name appearing on the goods may be the name of the dealer and the dealer may refuse to reveal who is the manufacturer. In many instances the manufacturer is a fly-by-night corporation from whom no valuable money recovery can be obtained while the selling organization may be entirely responsible financially. Again it may be that the individual inventor will find it impossible to go to the necessary expense of suing a manufacturer whose plant is located across the continent, and it would seem reasonable to allow the patentee to sue the person who is taking away his business by selling the device.

A further Department of Justice proposal, to have the Government take title to any patent improperly sold or licensed, seems to be open to more chance of abuse than is justified by the good it may do.

These proposals are against licenses under individual patents. The problem

of owners of several patents combining to grant licenses is not considered but may be more harmful to the public.

Senator O'Mahoney, Chairman of the Temporary National Economic Committee, after reviewing the testimony, said:

"The fact that patents are keystones in many very important industries has been brought home to us with great emphasis. There is practically unanimous agreement among witnesses [before the Temporary National Economic Committee] that Congress, by enactment of the Patent Law, has given this country a system far superior to that which exists in any other country." Obviously the best system in the world, which has worked satisfactorily on the whole, should be tampered with very slowly and should not be wrecked.

It may be that no effort will be made at once by the Department of Justice to procure such amendments to the patent law. Many think these matters should be taken care of under the anti-trust laws and the Government has recently begun litigation against parties whose activities were disclosed before the Temporary National Economic Committee, possibly to see how much the anti-trust laws will be interpreted to restrict activities under patents.

### *The Twenty-year Bill*

The Constitution authorizes patent protection only for "limited times." The statutes give a 17-year patent but this period has been greatly lengthened in some instances by delays in issuing the patent. It is therefore proposed in S. 2688, now in Congress, to limit the patent to 17 years from its issue or 20 years from the application date, whichever is shorter. Thus if an inventor keeps his application pending in the Patent Office for 5 years he will get a monopoly for only 15 years after issue of the patent. This will penalize a dilatory applicant and free the invention for the public sooner. Long delays in granting patents form unnecessary hazards to industry, by creating uncertainty and confusion. Long pendency has the effect of creating undue congestion in the Patent Office to the detriment of those who desire prompt action on their own cases, and also increases the likelihood of interferences.

Several changes in the law and Patent Office rules were made last year which may speed up applications somewhat but the need for this twenty-year bill remains.

Sometimes delays are not due to the applicant but to an opponent in a contest or to the Patent Office being behind with its work, but such cases are exceptional and possibly a few inventors should suffer rather than the whole public. The Patent Office delays may be made less if Congress passes another pending bill, H. R. 6721, which has already passed the House of Representatives, providing for an increased permanent corps in the Patent Office to perfect the classification of the prior art so it can be more expeditiously searched. Better classification will also tend to better assure that no improper patents will be granted and will also make the great bulk of information in patents better available to the public for its education. This will certainly promote science and useful arts.

### *One Court of Appeals*

The patent, being a grant of the Government, is co-extensive with the jurisdiction of the Government. It may be infringed in any part of the country and a suit for infringement of a patent may be brought in any United States District Court. The Federal judicial system consists of a number of trial courts having limited territorial jurisdiction. None of these covers more than one State, and many of them cover only part of a State. Direct appeals are not allowed to the Supreme Court in patent cases but appeals must be taken to the United States Circuit Courts of Appeals. The country is divided into ten judicial circuits, each limited in jurisdiction to a certain number of States.

If a patent infringement suit is brought in Massachusetts the appeal will be taken to the First Circuit Court of Appeals. The patent may be infringed by someone else in Ohio and an infringement suit brought there will be appealed to the Sixth Circuit Court of Appeals. The attitude of the different Circuit Courts of Appeals towards patents is different and on the very same record and with the very same circumstances it is possible that the First Circuit Court of Appeals will hold the patent invalid or not infringed and the Sixth Circuit Court of Appeals will hold the patent valid and infringed. Thus the patent may be valid and good in one part of the United States and invalid and not good in another part of the United States. In most instances of this sort the Supreme Court of the United States may grant a writ of certiorari and decide which of the Circuit Courts of Appeals is right. This, however, is expensive and may be long delayed and much dissatisfaction has been expressed.

It is proposed to establish a new Circuit Court of Patent Appeals which will have jurisdiction throughout the United States but only of suits involving an issue under the patent laws. The bill, S. 2687, was introduced into the Senate last year and there were hearings before the Patents Committee as a result of which the bill was favorably reported to the Senate and it is now on the Senate Calendar awaiting action.

The endeavor to get a single Court of Patent Appeals has been going on for upwards of forty years. Those in favor of such a Court point out that matters relating to patents are more or less technical and different from other matters and consequently may best be handled by a specially qualified court. They point out that it is desirable to have all patents considered by one court so that there may not be a difference in attitude toward different patents or even toward the same patent in different suits. They point out that a final determination may be procured more promptly than at present, when it is necessary to get diverging decisions of Circuit Courts of Appeals and then have the matter finally determined by the Supreme Court. The single Court of Patent Appeals has been recommended by the Temporary National Economic Committee; the President's Science Advisory Board; the American Association for the Advancement of Science; the National Association of Manufacturers and by a good many other business associations.

Nevertheless there is objection to such a court. Its opponents say that the President is likely to make political appointments to the court and the judges may therefore not be of the type in which confidence may be placed for deciding all the technical matters involved in patent litigation. The court will have its headquarters in Washington but the bill provides that it may move about the country and sit at suitable points as it desires but the opponents of the bill say it is but natural that the judges should sit in Washington only and require counsel throughout the country to come to Washington for all appeals. They also argue that no matter how good the judges on the court are they will in a short time become very narrow in their outlook because of having only one type of case before them.

### *Too Many Patent Appeals*

A partial reply to this is that in patent litigation many incidental questions come up. One opponent of the bill listed some score of legal issues not strictly patent law which might come before the court, which would seem to indicate that the court might not become narrow. It is urged that there are so many patent appeal cases at the present time handled by the ten Circuit Courts of Appeals that it would be impossible for a single court of appeals to handle them adequately. This objection might be increasingly valid if patent litigation increases with time. Indeed the existence of a single court of patent appeals might induce litigants to take more appeals than they do now to the divergent Circuit Courts of Appeals.

A system which has operated to give us the mighty advance in science and art of the past century and a half should be tampered with very cautiously.

*Official Photograph U. S. Army Air Corps*

***Streamlined contours with formed transparent plastic sheet are placed around pilot's and gunner's positions in the fast Bell "Airacuda"***

# TRANSPARENT PLASTICS

## *Designs for Mounting Sheets*

GERALD P. YOUNG
*Aeronautical Representative, Röhm & Haas Company*

EXPERIENCES with installation of transparent plastic sheet, such as the acrylic resins, in aircraft have emphasized the importance of certain design fundamentals. The light weight, colorless transparency, and high impact strength of transparent plastics have recommended their use in aircraft since they were first made commercially available in 1936. Recently, however, new methods of installation have been devised to take advantage of the peculiar properties of this type of plastic and thereby to increase its usefulness in aeronautical design, and point the way to increasing usefulness in other design fields.

An examination of these properties will reveal a number of reasons why transparent plastic sheet material has so rapidly replaced glass in many applications. For example, the specific gravity of Plexiglas, an acrylic resin widely used in aviation, is 1.18 to 1.19 as compared with approximately 2.5 for glass; and it is 91 per cent to 92 per cent efficient in transmitting light as compared with 88 per cent for glass.

Moreover, it is thermoplastic and can, therefore, be shaped when heated. In this way two- and three-dimensional curved sections may be obtained for turret and cockpit inclosures which more nearly conform to the streamlined design of the rest of the plane. Its high impact strength also obviates the necessity for cumbersome braces and supports which may obscure visibility.

The transparent plastics are readily cut and machined with ordinary woodworking tools. As no fillers are added to these plastics, the tools keep their edge well. Flat pieces can be cut on a circular saw and, if this is done with a fine-tooth blade, no further finishing of the edges is needed. Edges which are exposed, however, can be polished after sanding by means of fine polishing paste and fabric buffing wheels.

Beveled and routed edges can be cut with a joiner or router. Where holes are required, they can be drilled with the standard twist drill, but care must be exercised to avoid "grabbing" of the drill

and thereby tearing the hole. The twist drill should be ground at the cutting edge parallel to the axis of the drill to eliminate any lead it may have. Standard woodbits made with a brad point are desirable for holes from $\frac{3}{8}$ in. to about 1 in. in diameter. Larger holes can be cut with a fly-cutter.

Small notches can be cut along an edge by using a router or small coarse grinding head, and holding the piece so that the cut is made at right angles to the edge and in the plane of the sheet. If grinding is done at right angles to the sheet, it may chip and crack.

The sheets of plastic should by all means be masked before any layout or cutting is attempted. If not masked when received from the manufacturer, a suitable masking may be prepared by cementing a sheet of soft paper to the surfaces with a water solution of gelatin or a rubber adhesive. The surface of Plexiglas is highly polished and, because of the extreme clarity of the plastic, will show slight surface scratches. A further advantage of masking is that it allows a layout to be drawn on the paper from a template, and, when the piece is not to be formed, it can continue to protect the surface until installation is complete.

Frames for holding the transparent sections in place should take into account the size, shape, and service required of the window or inclosure. All flat sections and simple curved sections of less than 45 deg. arc can generally be installed in channels without drilling holes through the material. Although landing-light covers may be curved to an arc of more than 45 deg., they can also be set in simple channels. The sections are formed to follow the contour of the leading-edge of the wing.

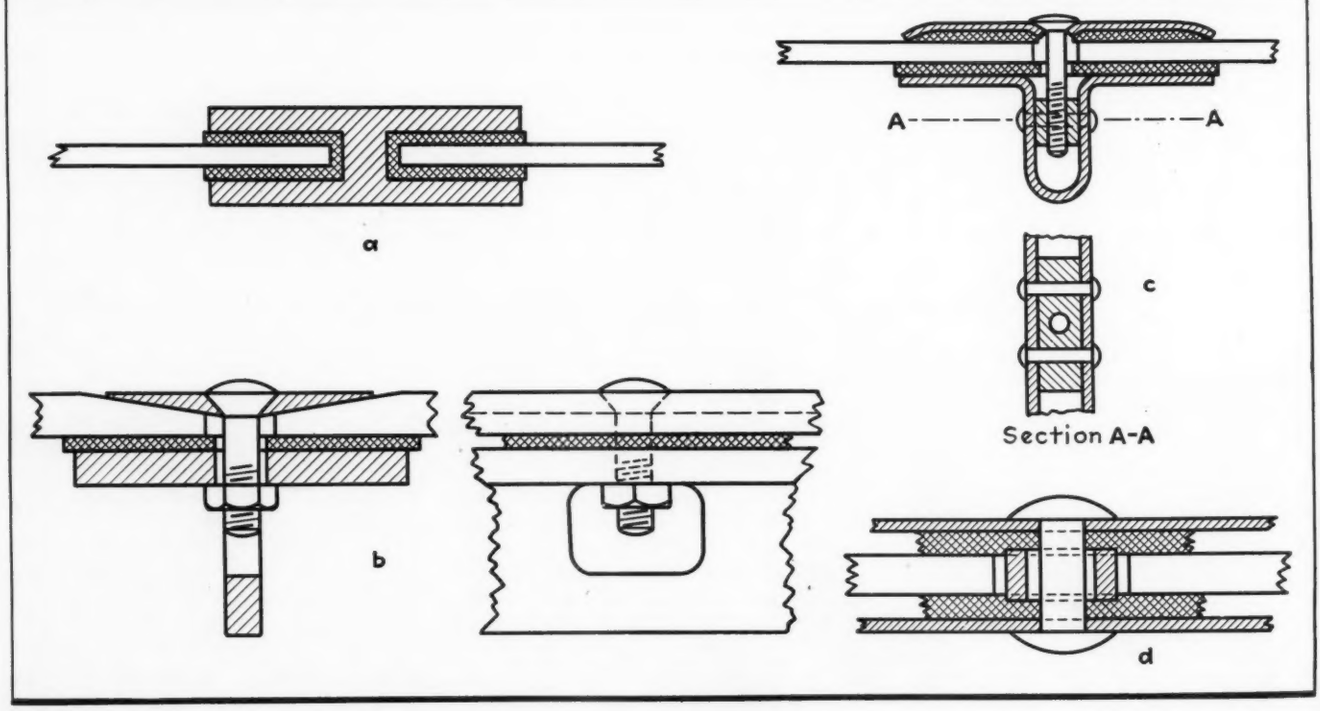
These channels can be strips of extruded metal or rubber section, or they can be fabricated from sheet metal with bolts or rivets holding the metal parts together. In either arrangement, there should be a layer of some packing material to make the joint water-tight.

Where the section is fitted into an extruded metal section, a tight joint is dependent upon the uniformity of the sheet and of the width of the channel. With fabricated channels the joint is made tight by pressure at the bolt or rivet holes. Care must be taken not to produce high stress in the plastic at these points. Acrylic resin plastics are quite elastic, but if clamped too tight the stress set up in the outer fibers will produce fine cracks about the point of stress. These fine cracks, called crazing, occur only on the surface, but they reduce transparency and undoubtedly weaken the material. As shown in the sketches below a shoulder rivet or a metal tube spacer a few thousandths of an inch larger than the thickness of the sheet may be inserted in the hole in the plastic to protect it from direct pressure.

The expansion coefficient of Plexiglas is $8 \times 10^{-5}$ in. per in. per deg. C. This means that a piece of material 10 in. long at 25 deg. C. would contract to 9.948 in. at $-40$ deg. C. and expand to 10.029 in. at 60 deg. C. If this absolute change in dimension were considered alone, it would be necessary to allow a plus clearance of 0.029 and a minus clearance of 0.052 in. But the channel material also expands and contracts. For example, the use of an aluminum alloy whose coefficient is $2.7 \times 10^{-5}$ reduces needed clearance by one-third.

When simple channels are used, the plastic can expand or contract by slippage in the channels and, with small sections, it is also possible to hold one

## TYPICAL MOUNTINGS FOR




**(a)**—Connection made by forcing a plastic sheet into an aluminum H-section, packing is a rubberized fabric.

**(b)**—In thicker sections, where the edge of the sheet is beveled, a double-wedged top metal strip can be used, leaving the outer surface smooth. Base channel to which sheet is bolted is an extruded T-section with cutouts in the web for the bolt and nut.

**(c)**—Two sections of plastic sheet are mounted with formed sheet aluminum alloy channel and elastic stop nuts. These stop nuts are small rectangular blocks of aluminum alloy threaded in one direction and with two small holes for rivets at right angles to the bolt hole. Called Plexiglas Elastic Stop Nuts, these were developed by the Douglas Company and were made by the Elastic Stop Nut Corporation.

**(d)**—The use of spacers around each rivet prevents excessive clamping stresses being set up in the plastic sheet.

end fixed and allow for all the expansion at the other end.

When the larger sections are used, however, more allowance should be made. A long narrow window 60 in. long at normal temperature, for example, would contract to 59.688 in. at —40 deg. C. and would expand to 60.174 in. at 60 deg. C. Under such conditions allowance may be made for expansion by holding the center of the long edge fast in position by a bolt and allowing each end to extend freely in the supporting channel.

Wherever the size of the section or design of the frame makes it necessary to drill holes through the plastic and bolt or rivet it to supporting members, the holes in the plastic must be oversize so as to allow some slight movement in the plastic relative to the metal frame. If the holes in the frame and in the plastic are drilled at the same time, the plastic should be removed and the holes redrilled to the larger size. These oversize holes must be made concentric to the ones in the frame so that the bolt or rivet does not bind at one edge, causing crazing or failure at these points.

In sections of hemispherical shape similar to an airplane nose or gun turret section, temperature changes will cause the spherical surface to expand as unsupported area. This expansion gives no trouble with pieces up to 40 in. in diameter, but it is important that the edge where the section is attached to the supporting frame allow for radial change by elongating the holes in the supporting attachment.

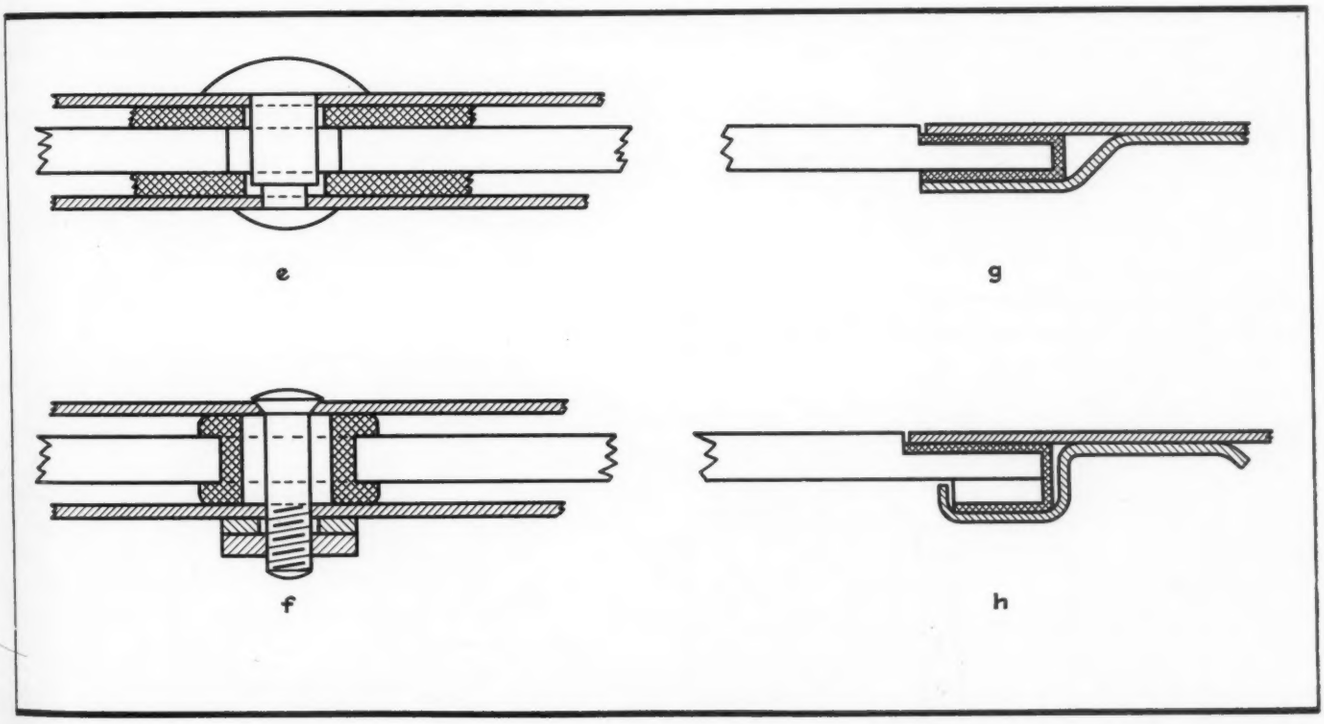
The aircraft industry requires that there be no corners on the outside of window installations to set up a parasite drag. One of the advantages of acrylic resin sheet is that the edges of the piece can be routed and set flush with the outside surface of the frame. Reinforcements, as shown in the sketches, permit routing the edges of thinner sheets in this type of installation.

The proper sheet thickness for any application depends on the conditions to which it will be exposed, the size of the section, and the shape of the section. The thinner sheets 0.060 to 0.100 in. of acrylic resin, such as Plexiglas, are sufficiently strong for low-speed aircraft and gliders. Landing-light cover glasses are usually made from 0.150 in. to 0.180 in. sheets, which are sufficiently thick to allow for a routed edge for a flush outer surface as described. Sections in high-speed aircraft, when less than 1 sq.ft. in area, are usually of 0.120 in. sheet; but when the areas become larger, thicker materials are used. Curved windshield sections, for example, with a span of more than 20 in. should be 0.200 to 0.250 in. Flat sheet for use as substitutes for laminated glass may be any thickness up to 1½ in. to give the required impact strength and rigidity.

A multi-section turret may use 0.125 in. material when, as indicated, the arc does not exceed 45 deg. These sections may often be subjected to the internal pressure due to air flow over their surface, and, if formed on too long an arc, may be sucked out of their channel unless riveted or bolted in place.

These methods of installation by no means exhaust the possibilities, but may serve as a guide to future consideration of the problem. Such consideration is more than justified, for installations which take advantage of the material's properties as a thermoplastic, even though it may be serving the purpose of silicate glass, will pay dividends in longer, more satisfactory service under a wide variety of conditions.

## TRANSPARENT PLASTIC SHEETS




**(e)**—Shoulder rivets can be used to mount two adjoining sections, or edge of one section of plastic sheet. This method requires that the hole in the top channel strip be of different size than the one in the bottom channel strip. This, with the shoulder on the rivet, prevents drawing the channel tightly against the sheet and allows for expansion or contraction.

**(f)**—Plastic sheets may be mounted at the edge section using a rubber grommet or bushing. The hole in the sheet is large enough to hold the grommet and the bolt passes through the center. The joint is not water-tight.

**(g)**—By routing, the outer surface may be made flush to give an unbroken smooth surface that will have a minimum of air resistance. This can also be applied to cars.

**(h)**—A routed section with a cemented reinforcement strip along the inside edge permits the section to be installed as a window from the inside with the outer surface flush.

# PEDALS AND FOOT

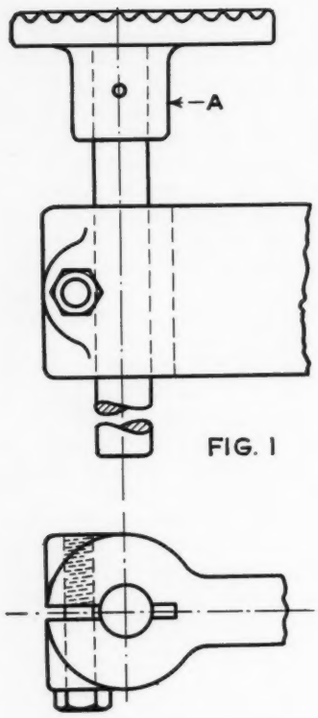



FIG. 1

Fig. 1—Rectangular treadle *A* is pinned to a round rod which can be clamped at variable heights in the foot lever. The end of the foot lever is drilled, tapped and then slotted as shown to obtain clamp.

Fig. 2—Tread pad *D* and pivot casting *B* are parts of an adjustable treadle designed to accommodate long or short-legged operators, and which can be adjusted in reference to the machine to suit operator's convenience. Lever arm is round stock bent into a U-form, the two legs of which pass through the holes *A–A* in the tread pad bosses and also through the holes in the two pivot castings *B*.

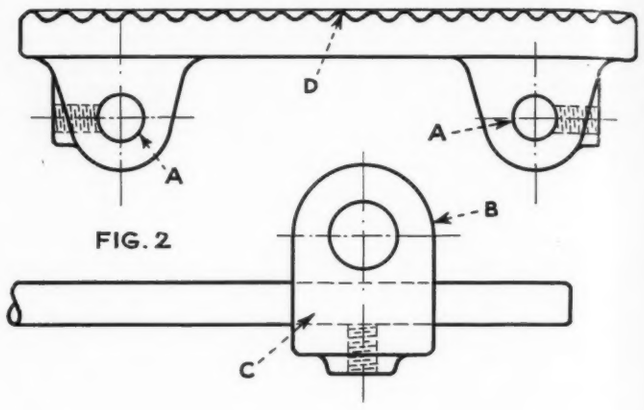



FIG. 2

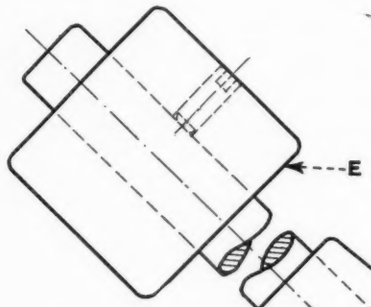
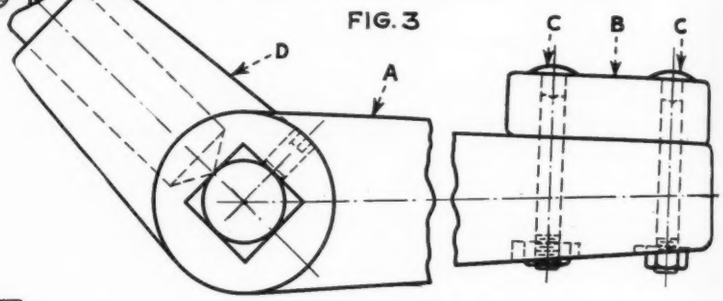



Fig. 3—In this arrangement, two cast iron levers *A* are positioned on a square shaft by set screws. On the outer ends of levers *A* a board *B* is fastened by carriage bolts *C*. Board *B* runs the width or the length of the machine. To avoid interference with other machine parts there is mounted slidably upon the square shaft, between the levers *A*, a cast iron arm *D* into which is driven a round rod. A weight *E* on the rod can be fixed at a suitable position to secure counterbalance.

FIG. 3



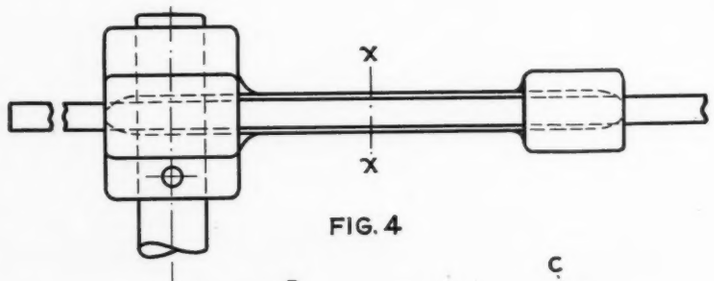




FIG. 4

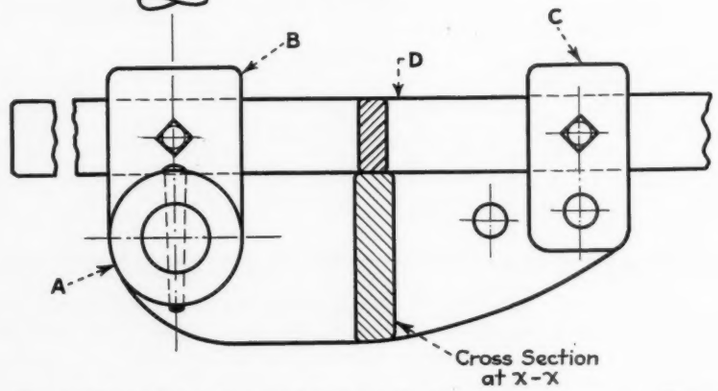



Fig. 4—Casting *A* is fastened to pivot shaft with a taper pin. The bosses *B* and *C* on casting *A* have cored rectangular holes through which the pedal extension lever can slide, set screws fasten the lever in the desired position.

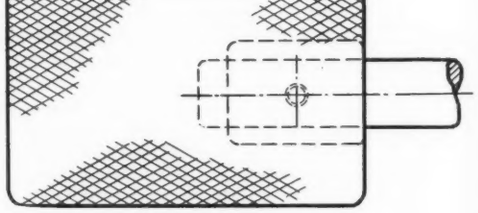


FIG. 5

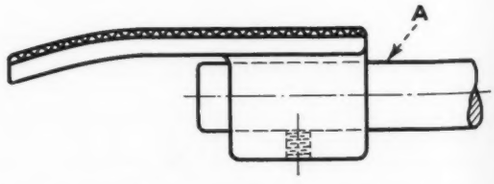



Fig. 5—Adjustable foot pad for round lever rods. The pad is slightly curved for operator convenience. As illustrated the foot pad can be rotated on the rod to obtain position desired. To keep the face of the pad parallel with the floor a flat can be milled on the rod for the set screw to bear against.

# OPERATED LEVERS

FRED ADAMS

WHEN choosing and designing any form of pedal arrangement, the designer should take into consideration a number of factors such as: should the treadle pad accommodate a man's or a woman's shoe, does the operator stand or sit while operating the machine, is an additional foot pad desirable for the "at-rest" position to lessen fatigue, should the pedal level be close-coupled, or adjustable for various operating positions. Whether the parts should be cast or fabricated and welded depends largely on the quantity needed and production facilities.

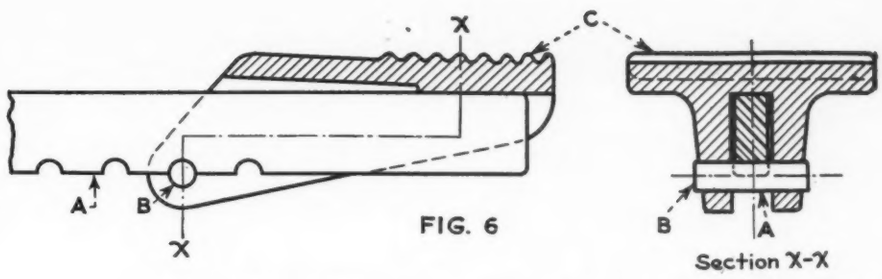



Fig. 6—Lever of rectangular section is notched on lower side with a series of semi-circular slots. Pin *B* is driven into the side flanges of the foot pad *C*. By lifting and sliding the outer end of the foot pad, it can be moved so that pin *B* will lock with any selected notch.

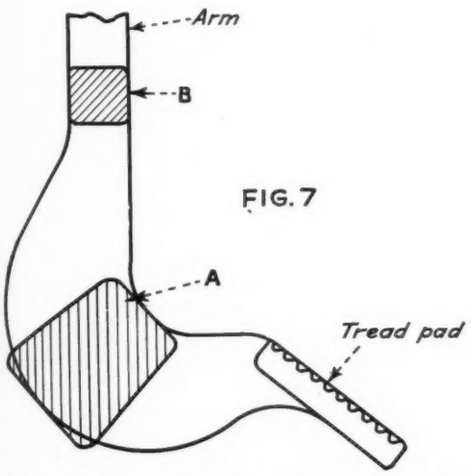



Fig. 7—A treadle designed to hang from the mechanism it actuates so that the arm is vertical in the idle position. At the knee behind the tread pad the section as shown at *A* is flared in order to increase the weight and to assure a gravity return. In this design there are no drilled or cored holes, neither is there any need for springs, pins or screws.

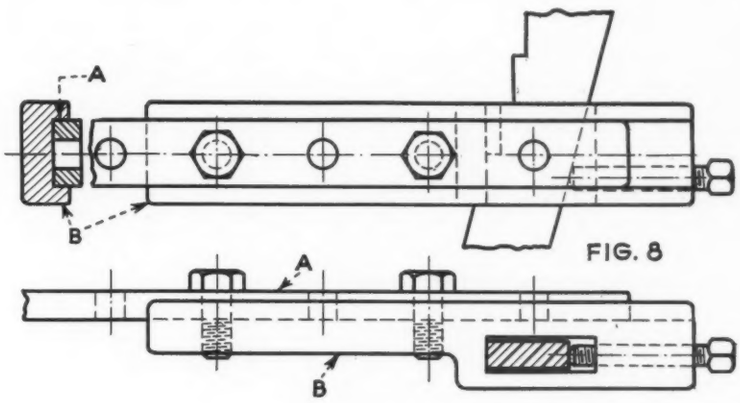



Fig. 8—An adjusting arrangement for a lever similar to that shown in Fig. 10. Forward and backward positioning is made by sliding the foot lever along the cast slot *A* in block *B* and bolting.

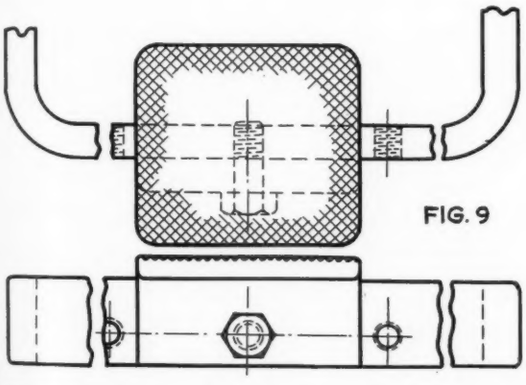



Fig. 9—Foot lever made of rectangular bar stock, drilled and tapped at suitable intervals for position tread pad. The cast iron tread has a flange at right angles through which a tap bolt passes and engages one of the tapped holes in bar.

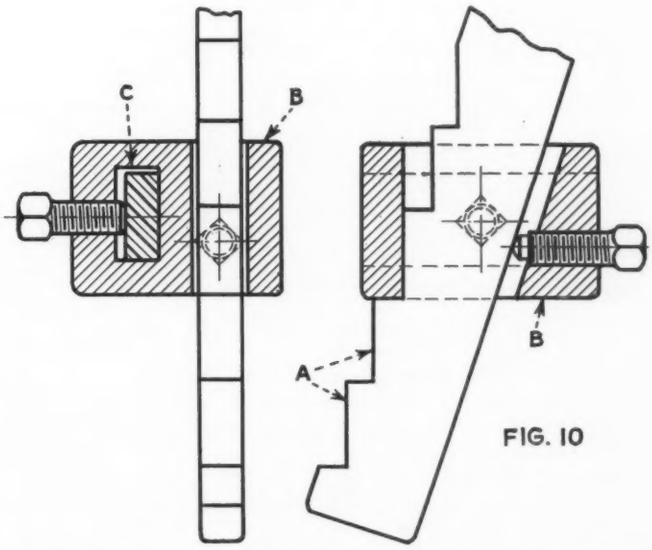



Fig. 10.—Operating extension lever, which connects with the tripping or the clutching mechanism, is notched with angular steps *A*. In order to secure desired leverage the cast iron block *B* can be fixed on any step by locking set screw. Slot *C* accommodates the foot lever proper which is adjustable lengthwise.

# Question and Comment

## Effect of Temperature on Resistance of Copper Wire in Magnet Coils

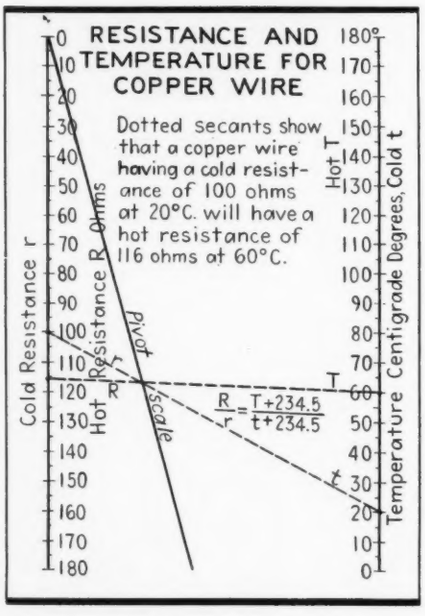
*To the Editor:*

In the series of articles on "Magnet Coils" by Mr. Graham Lee Moses on page 48 of the January PRODUCT ENGINEERING he cites the well-known formula for the variation of resistance of copper wire with temperature

$$\frac{R}{r} = \frac{T + 234.5}{t + 234.5}$$

In this $R$ and $r$ are hot and cold resistances at $T$ and $t$, the respective temperatures in Centigrade degrees.

The writer has made a very convenient monogram or double Z-chart for the solution of this equation, in which any


RESISTANCE AND TEMPERATURE FOR COPPER WIRE
Dotted secants show that a copper wire having a cold resistance of 100 ohms at 20°C. will have a hot resistance of 116 ohms at 60°C.
Cold Resistance r
Hot Resistance R, Ohms
Pivot Scale
Hot T
Temperature Centigrade Degrees, Cold t
R/r = T+234.5 / t+234.5

pair of computing secants intersecting on the inclined pivot scale cuts out four values of the variables that satisfy the equation. Thus any three may be assumed and the fourth found. The dotted secants show that a 40 deg. rise from 20 deg. on a 100-ohm resistance increases it to 116 ohms (or more accurately 115.7 ohms).

However, equal rises do not produce equal resistance increments. It will be found that a 40 deg. rise, starting at 0 deg. on a 100-ohm resistance, will increase it to 117.0 ohms, while the same rise from 140 deg. will only increase it to 110.5 ohms. This feature may be seen from the equation, which is hyperbolic in form; also from the computing secants themselves. Of course the resistance scales may represent any multiple of 10. This equation probably follows the actual law over a large variation of temperature, and is particularly applicable to coils with the new fabric glass insulation which may be operated at quite high temperatures.

Another formula giving results practically identical, but over a more restricted range, is often used, viz:

$$R = r\,[1 + 0.00393\ (T - t)]$$

This is a rectilinear law, stating that the resistance increases 0.393 per cent for each degree Centigrade rise. For 40 deg. rise, the 100-ohm resistance would thereby increase to 115.7 ohms, starting at any cold resistance whatever, which is the same result as from the nomogram formula starting at 20 degrees Centigrade.

—CARL P. NACHOD
*Nachod & United States Signal Co.*

*To the Editor:*

In the February 1939 issue of PRODUCT ENGINEERING, pages 85 and 86, there is an article on heat effects on magnet coils by Mr. Graham Lee Moses of Westinghouse Electric & Manufacturing Company. In Fig. 2 of this article is a set of curves showing the effect of temperature on the resistance of copper at various ambient temperatures.

After checking these curves and the formulas included in the article, from which they were plotted, we believe that the curves for 0 deg. C. ambient and 50 deg. C. ambient should be interchanged.

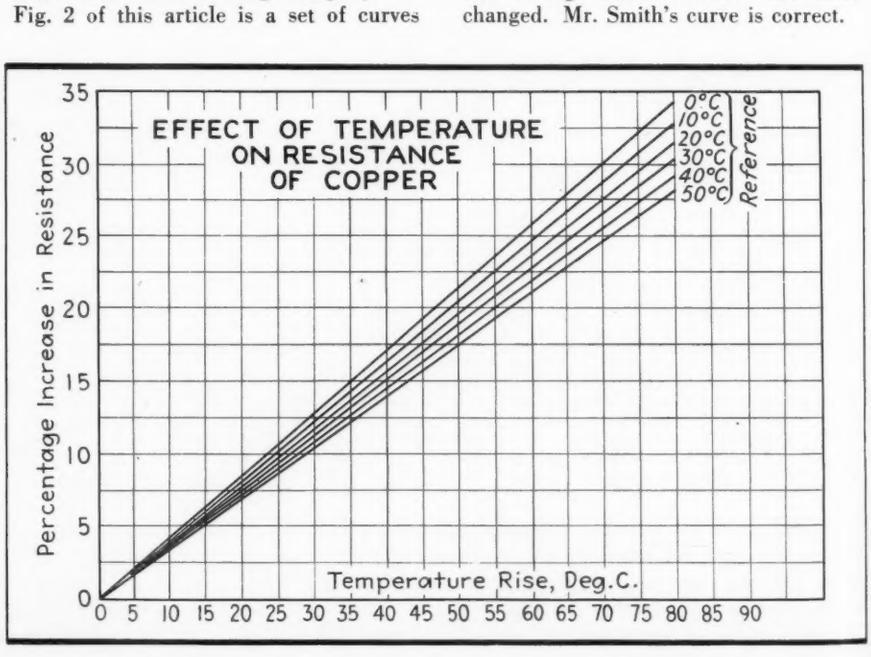
Also these curves do not directly take care of the condition where the initial or reference temperature of the copper is different from the ambient temperature.

We have prepared a set of curves to serve the purpose of the curves which you published, based on initial or reference temperatures and plotted by use of the same basic formulas used by Mr. Moses. In using these curves we measure the initial or reference temperature and the corresponding resistance and the final resistance. The percentage increase in resistance is then computed, the corresponding rise is read directly from the curves, and the rise added to the initial temperature to get the final temperature. The rise above ambient is then found by subtracting the ambient from the final temperature.

A. V. SMITH
*Homelite Corporation*

*To the Editor:*

Thanks for Mr. A. V. Smith's letter calling my attention to the error in my article in the February 1939 issue of PRODUCT ENGINEERING. He is quite right. By a clerical error the 50 deg. ambient and 0 deg. ambient curves are interchanged. Mr. Smith's curve is correct.



My reference to ambient temperature is based on the assumption that, when the resistance of apparatus is measured, it is at ambient temperature. I agree that where "reference" and "ambient" temperatures are not identical this should be clearly distinguished. We find it useful to correct observed cold resistance values to a common base. For our purposes we use 25 deg C. (77 deg. F.) because it so closely corresponds to our factory and laboratory ambient temperature. Thus you see we actually only use the 25 deg. C. curve.

A simple, quick, and accurate method of changing resistance values from one temperature to another or determining temperature by resistance using a slide rule is as follows. On both the slide rule setting is the same, the only difference being the mental approach.

To determinine per cent resistance change because of temperature: Divide 1 by $(234.5 + T)$ where $T$ is the reference temperature Centigrade at which the cold resistance is known, the quotient is of course the temperature coefficient of resistance. Multiply the quotient by the rise by resistance to determine the percentage change caused by temperature. This is a simple slide rule operation.

To determine the temperature rise by resistance: Divide 1 by $(234.5 + T)$. Then determine the multiplier which will give the product equal to the percentage resistance change. This multiplier is the rise by resistance.—GRAHAM LEE MOSES
*Westinghouse Electric & Mfg. Company*

## Relative Opening of Circular Orifices

*To the Editor:*

The chart in the Figure gives ratio of the area of opening of circular orifices to the area of same relating to certain shifting $S$ of the disk or plate having rounded $R_2$, or straight $R_2=\infty$, working edges. The fundamental formulas for determining area ratio $K$ are written as follows:

With upper position of the working edge of the disk:

$$K = \frac{\beta}{180} - \frac{\sin 2\beta}{2\pi} - \left(\frac{R_2}{R_1}\right)^2 \left(\frac{\alpha}{180} - \frac{\sin 2\alpha}{2\pi}\right)$$

With lower position of the working edge:

$$K = 1 - \left[\frac{\beta}{180} - \frac{\sin 2\beta}{2\pi} + \left(\frac{R_2}{R_1}\right)^2 \left(\frac{\alpha}{180} - \frac{\sin 2\alpha}{2\pi}\right)\right]$$

$$\text{Cos } \beta = \frac{A^2 + n^2 - 1}{2An},$$

$$\text{in which } A = \frac{S}{R_1} + n - 1;\ n = \frac{R_2}{R_1}$$

Example: Determine the opening area of 6 in. gate valve corresponding to 1½ in. shifting of gate. From the point in the bottom scale designating

$$\frac{S}{2R_1} = \frac{1.5}{6} = 0.25$$

trace vertically to the curves $\frac{R_2}{R_1}$. The points of intersections thus obtained will indicate on the vertical scale corresponding values of $K$ equal to 0.2, 0.238, 0.265 and 0.312 at respective ratio $\frac{R_2}{R_1}$ equal to $\infty$, 2, 1.25 and 1. Opening areas will then be 5.66, 6.73, 7.5 and 8.83 square inches.

—VICTOR TATARINOFF

## Corrections in Cam Rise and Fall Formula

*To the Editor:*

The article "Simplified Formula for Cam Rise and Fall" which appeared in the Question and Comment section of the February number of PRODUCT ENGINEERING, as presented contains errors which I hasten to call to your attention.

At the end of the third paragraph the equation for $E$, perhaps for the sake of clarity should have designated $E_{max}$, since the equation is for the maximum value.

In the middle of the fifth paragraph, first column, the phrase "remaining on the line contacting their centers" should be "remaining on the line connecting their centers."

An error which might seriously mislead a reader occurs at the beginning of the first column. The paragraph as printed starts, "The angle $\theta$ on the diagram . . .", this should read "the angle $\phi$ on the diagram . . . ."

In reference to the last paragraph the "short-cut" formulas for which so small an error is claimed are Equations (6) and (7), not Equation (1) as stated. Equation (1) introduces a much greater error. If $R = A/10$, the maximum error equals $R^2/2A - R/20$, or $0.05R$, a value 4,000 times as great as the maximum error when the short-cut Equations (6) and (7) are used. As mentioned just above the last paragraph, Equations (6) and (7) are derived from Equations (2) and (3) for the purpose of shortening the work.

Last and least, you omitted the final "s" from my name under the title.

—H. A. BOWERS
*Mariemont, Ohio*

[*Editor's Note*—Our sincere apologies to Mr. Bowers for misspelling his name. The errors are all ours. We sincerely thank Mr. Bowers for calling the errors to our attention.]

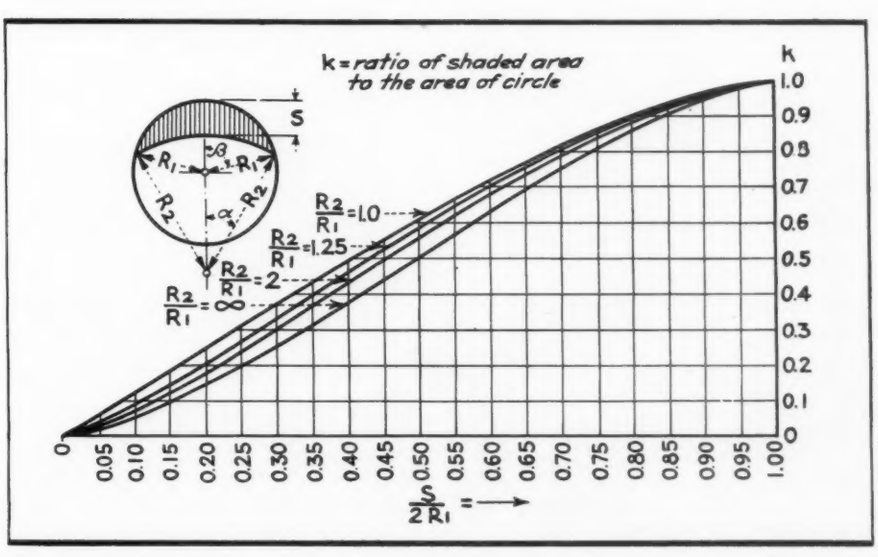
## More On Dampers

*To the Editor:*

Two dampers have been developed by the aircraft engine industry which should be of general interest. Patents on these were issued probably too late to be included in D. Gerdan's article in January and February, 1940, PRODUCT ENGINEERING.

W. G. Lundquist (Patent No. 2,172,741) has arranged the parts of the damper so that the torsional vibration is suppressed at the crankpin, the point of application of the vibration loads, thus practically eliminating stress fluctuation in the crankcheek. Annular rings fitted to the crankpin on each side of the connecting rod act as tracks for two annular damping elements.

With the crankshaft rotating at normal speed the disks will be thrown out from the crankpin. They will lag rotationally when a torsional impulse is transmitted to the crankpin. Centrifugal force will restore them toward a radial position when the impulse is relieved. In doing so the disks will overrun the radial position thus providing a torsional impulse opposite in



phase to that of the original impulse.

A damper which uses a liquid such as mercury instead of a pendulous weight has been patented by W. L. Fischer (Patent No. 2,180,351).

The mercury and its cartridge are arranged according to the basic formula

$$L = \frac{R'}{H^2}$$

where $L$ is the distance of the center of gravity of mercury from the center of the cavity, $R'$ is the distance from axis of rotation of the shaft to the center of the cavity and $H$ is the number of vibrations per revolution to be suppressed.

—S. KALAGAIN
*Chicago, Ill.*

## Chain or Cable Crowd

*To the Editor:*

I have looked over the road show section of the recent issue of PRODUCT ENGINEERING and I am a little surprised at the editorial statement on the bottom of page 85 in regard to the chain crowd of the Bay City Company of Michigan.

For your general information the Northwest Engineering Company has used a cable crowd during its entire manufacture, covering almost twenty years. The Bucyrus-Erie Company on its larger machines from four years and up have used nothing but a cable crowd.

The chain crowd has a great many bad features. I think that a publication makes a mistake from an editorial policy standpoint when it makes sweeping statements that are odious comparisons and are not supported by facts. It seems to me that editorial ethics have been violated.

—R.T.G.
*Chicago, Ill.*

[*Editor's Note:* We must plead guilty to the charge of violating editorial ethics and making sweeping comparisons. As implied above, the question of the relative merits of chain crowd versus cable crowd will be affected by the size and type of shovel. Each has its points of superiority and also its disadvantages; both have been found satisfactory.]

# *Can You Work This One?*

H. E. SMITH

*This month's problem—*

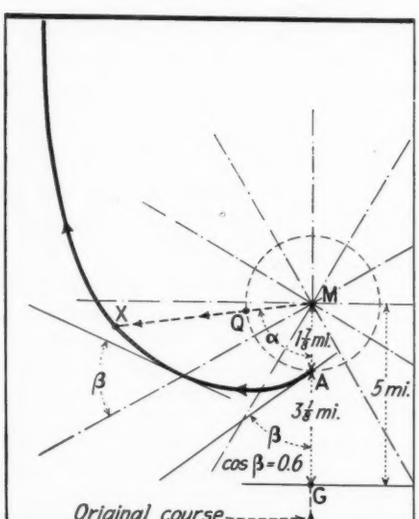
### *Honest Monkey*

Legend has it that five sailors and a monkey were shipwrecked on an island and spent the day gathering cocoanuts which they threw into a large pile and agreed to divide evenly the next morning. They were suspicious of each other, however, so first one stole away from his comrades and divided the big pile into five equal piles and had one cocoanut left over which he saved for the monkey. He then hid one of the five piles away and pushed the other four together, including the one for the monkey. Shortly afterwards a second sailor came out, divided the remaining large pile into five piles, had one cocoanut left over which he also saved for the monkey. Then he hid one of the piles and pushed the other four together, with the one for the monkey included. Each one of the three remaining sailors did exactly the same thing, and when morning came it was found that the remaining pile could be divided evenly among the five. What is the least number of cocoanuts there could have been in the original pile?

*Solution to February problem—*

### *A Matter of Course*

Should the merchantman attempt to turn about and retrace his previous course, the captain of the gunboat to make a catch decided to hold his speed of 25 mi. per hr. and to keep on his course in line with the spot $M$, 5 mi. away, where the fog intercepted his view of the merchantman, which the gunboat captain assumed would maintain a speed of 15 mi. per hr. on some straight line course from $M$ radially.




The gunboat captain divided the distance $GM$, 5 mi., into two parts proportional to the speed of the two boats, such that

$$GA = \left(\frac{25}{15 + 25}\right) \times 5 = 3\tfrac{1}{8} \text{ mi.}$$

$$MA = \left(\frac{15}{15 + 25}\right) \times 5 = 1\tfrac{7}{8} \text{ mi.}$$

Now assuming that the merchantman did not take the course from $M$ to $A$, the gunboat captain knew from their respective speeds that the merchantman would be at some point 1⅞ mi. radial distance from $M$. The gunboat captain on arriving at $A$ changed his course to a curve which would cut all radii from $M$ to his future consecutive positions at a constant angle β, such that the length of the course from $A$ to any position on his curve would be 25/15 of the radial distance from $MQA$ circle.

Being a good navigator, the gunboat captain was also a good mathematician, he knew from these conditions that his course would be a logarithmic spiral following the polar equation

$$r = ae^{k\alpha} \qquad (1)$$

in which $a$ is the value of $r$ when $\alpha = 0$, $k$ is the cotangent of the constant angle β, and that the curvilinear length between any two points on the spiral would be $(r_1 - r_0)/\cos\beta$. In order to catch the merchantman, the gunboat's time to sail the curvilinear distance $(r_1 - r_0)/\cos\beta$ must equal the merchantman's time to sail the radial distance $(r_1 - r_0)$. Therefore solving

$$(r - 1\tfrac{7}{8}) \times \frac{25}{15} = (r - 1\tfrac{7}{8}) \,/\, \cos\beta$$

the gunboat captain calculated the value of cos β to be 0.60000, or β to equal 53 deg. 7 min. 19/24 sec. (that is, if he used the same set of trig tables that the writer owns) and plotted his course accordingly. The gun boat captain being a self confident chap stopped calculating here and made for his prey.

If any reader is still interested and would like to plot the curve for a revolution or so, here is the rest of the data.

Putting Equation 1 in logarithmic form, it becomes

$$\log r = \log a + \log e^{k\alpha} = \log a + k\alpha \log e \qquad (2)$$

in which when $\alpha = 0$, $r = 1\tfrac{7}{8}$ mi., and from Equation (2)

$$\log r = \log a + o$$

or $a = r = 1\tfrac{7}{8}$ mi., $\log 1\tfrac{7}{8} = 0.27300$

Since $k$ is the cotangent of β, its value 0.7500 can be found from trig tables.

$$e = 2.71828, \quad \log e = 0.434294$$

Substituting these values in Equation 2, the polar equation for the gunboat's course expressed in logarithmic form, with α in radians is

$$\log r = 0.27300 + \alpha \times 0.3257205$$

# News and Summaries

## *America's Modern Pioneers Honored*

**Celebration marking 150th anniversary of the founding of American Patent System honors Heroes of Industry's workshops and laboratories**

CLIMAXING a study that began last July, scrolls of honor were awarded during the month of February to approximately 500 Heroes of Industry's workshops and laboratories throughout the nation at a series of regional banquets, and Modern Pioneer plaques for national recognition were presented to nineteen inventors and research workers at a national celebration banquet on February 27 held in New York City.

Those honored were selected by a group of eminent scientists from among more than 1,000 nominees as the nation's outstanding creators of new products, new industries and new jobs during the last quarter century. They were judged by the committee on the merits of their inventions and discoveries as factors in the nation's progress and as contributions to the American standard of living.

Civic and trade groups and industrial associations sponsored the programs in the 14 regional areas. The national program celebrated in New York was sponsored by the National Association of Manufacturers. Leaders in the field of science, industry and government participated in honoring those designated for national honors. The program was broadcast on a coast-to-coast radio hook-up.

The National Association of Manufacturers, accepting its responsibility to preserve and improve the private enterprise system in this country, joined with industrialists, inventors, scientists, industrial associations and the patent bar in sponsoring the nation-wide "Modern Pioneers Celebration," to mark the 150th anniversary of the founding of the American Patent System and to focus public attention upon the vital importance of the patent system to American progress.

Among those who received national awards are: Dr. Leo Hendrik Baekeland, one of the founders of the plastics industry; Willis Haviland Carrier, a pioneer in the field of air conditioning; William David Coolidge, inventor of ductile tungsten who has made inestimable contributions to electrical engineering, medicine and radiology; Dr. Lee de Forest, a pioneer in the development of wireless telegraphy in America; Henry Ford, through his genius in mass production has made automobiles available to millions of American families; Charles Franklin Kettering, for his many inventions in the fields of electric starting of automobiles, refrigeration units, and farm lighting; Dr. Irving Langmuir, inventor of the gas filled electric lamp; John B. Tytus, for work done in the development of the cold process of rolling steel; Orville Wright, who with his brother was the first successfully to fly an airplane; and inventors of Nylon, ten men who produced a synthetic fabric to take the place of silk.

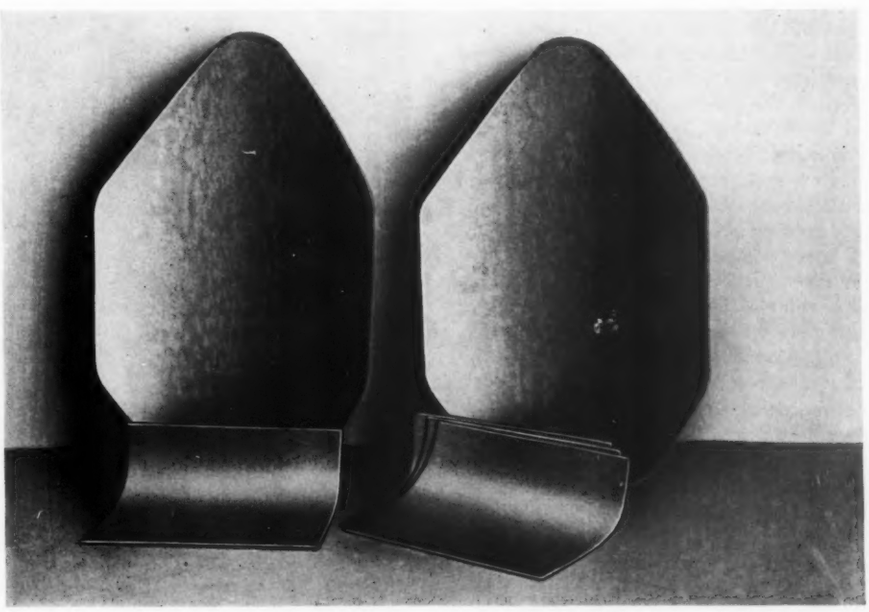
## *Light Armor Plate*

ONE of the latest developments in the application of steel to wartime purposes is the use of light armor plate for the protection of airplane pilots from machine gun and anti-aircraft fire, according to the Jessop Steel Co., who report that they have just completed shipment on a large number of sets of armor plate to be installed in the cockpits of combat planes. Two sets of these armor plates are shown in the accompanying illustration. These pieces are so placed as to afford protection to fire from below and from the rear.

In order to procure maximum ballistic resistance to penetration, the armor plate is specially heat-treated. As a result, it is possible to use a comparatively thin gage steel and thus reduce weight of the pieces to a minimum, while fully protecting the pilot. Sheets and plates can be furnished which will withstand 0.38 and 0.45 calibre pistol and sub-machine gun bullets, as well as 0.30 calibre Springfield rifle fire.

## *New Steel Process*

IN NO BRANCH of metal fabrication has more effort been made than in that of combining the new and expensive "stainless steels" with the cheaper and stronger carbon steels. Considerable progress has been made and many difficulties have been overcome in the production of stainless clad materials. One method consists of heating slabs of the two metals in contact and then rolling or forging the combination. A second method is that of pouring the liquid melt of carbon steel around a solid section of stainless steel. A third method has been to build up a series of thick overlapping beads of stainless steel weld rod deposit



*Thin gage armor plate for installation in the cockpits of combat planes*

on a carbon steel backing, then machining the surface and rolling the combination to finished size. Success has also been achieved by the method of placing a thin sheet of stainless steel upon a steel plate of proper thickness and then spot welding them together on close centers by electrical resistance methods.

Robert K. Hopkins, director of metallurgical research for the M. W. Kellogg Co. of Jersey City, N. J., was convinced that in order to obtain a material that would fulfill the requirements of the petroleum industry for pressure vessels, it would be necessary to depart radically from all previously conceived methods and that the desired result could be accomplished only by the development of a new melting technique. Research was started and a thorough investigation was made of all known melting processes.

After intensive investigation, a special type of electric arc melting furnace was designed and constructed in which the melting operation could be carried on and the final product could be intermelted with any other metal part and allowed to solidify as an inseparable portion of the unit mass.

Long association with Allegheny Ludlum Steel Corp. and recognition of their experience in the production of stainless steels, prompted Mr. Hopkins to discuss the problem with the Allegheny Ludlum research staff and as a result the steel company decided to participate in the further development. This work culminated in the construction of a plant at Brackenridge, Pa., which is now in commercial operation under exclusive license from The M. W. Kellogg Company under the Hopkins patents.

Pluramelt, the name of the new process, in its numerous analyses is the product of an electric furnace melting technique, as a result of which all of the special composition materials and a small part of the low-cost materials are melted and integrally joined during this operation. In the furnace proper the functions of steel making and of the mold are combined. In this way special steels are melted and joined to low-cost steels in ingot form, to produce Pluramelt ingots. The process produces single ingots of two or more compositions, integrally bonded together, and it is possible to change the composition, within limits, during the melting operation.

Experience so far has been limited to Pluramelts of stainless alloys (high chromium-iron and chromium-nickel-iron alloys) on soft or medium steel, and tool steel types on soft steel bases, but it seems very likely that the commercial success with these materials may be duplicated with any other alloy that can be melted in an arc furnace. The base metal can be covered on both sides and triple or more layers made of any desired proportionate thickness.

## *Photographing Arcs Under Water*

FROM long experience with oil circuit breakers and other electrical apparatus scientists know that an alternating-current arc in a fluid may be extinguished faster if the fluid is in motion—but nobody knows exactly why. Fundamental studies of arcs over a period of many years have yielded a wealth of knowledge about the performance of arcs, and circuit-interrupting devices have been improved rapidly as a result.

Dr. Slepian, associate director of the Westinghouse Research Laboratories, believed that the motion of gas bubbles liberated by the arc from the surrounding fluid was responsible for the anomaly. He enlisted the aid of Dr. T. E. Browne, Jr., and together they have worked out a method of photographing arcs under water. Because an arc either lives or dies as a result of what happens just before the instant at which its current falls to zero, most of the pictures are taken during that brief, chaotic struggle against extinction. From a rogues' gallery of more than a thousand pictures, Dr. Browne has found that an abundance of gas between the electrodes at this critical instant seems to breathe new life into the arc, while its death pangs are almost always presaged by a relative dearth of gas within the bubbles. One of the most interesting things discovered from a study of the pictures, however, is that the arc bubble apparently expands and contracts very rapidly at a frequency which bears no relation to the electrical frequency of the system, but which depends on how fast the water flows past the electrodes.

The apparatus used for these pictures is simple in principle, though somewhat complex in detail. Arcing electrodes are mounted inside a vertical steel cylinder

*Apparatus for under-water arc photography. Exposure is made through a slotted disk rotating in front of the miniature camera lens. Dr. T. E. Browne, at left, is demonstrating the operation of the mechanism and sequence of procedure to Dr. Slepian, at right*

3 in. in diam. through which the water is pumped upward at velocities as high as 200 ft. per sec. On opposite sides of the cylinder are circular windows. For photographing the arc, a miniature camera equipped with supplementary portrait lenses is placed before one window, and the other window is brightly illuminated to make bubbles around the arc appear as silhouettes against a light background.

Exposures averaging about 1/3,000 second are made through a slotted disk, which is driven by a small synchronous motor. Contacts on a rotating drum attached to the shutter disk synchronize the camera shutter and record on an oscillogram the exact instant at which the picture is taken.

Although these arcs were studied under water, it is reasonable to expect that oil circuit breakers will be improved as a result. The same photographic methods have been used successfully in studying arcs in oil, the only difference being that good pictures are a little difficult to get because the color of the oil obscures detail slightly and necessitates more background illumination to get good silhouettes of bubbles.

## *Network Television Demonstrated to FCC*

NETWORK TELEVISION, the dream of scientists for years, was demonstrated successfully to Federal Communications Commission members in Schenectady Feb. 1 by General Electric engineers. The first demonstration of its kind in history, in which a program transmitted from New York was clearly received in Schenectady homes, was made possible by the use of General Electric's new relay station working in conjunction with its main transmitter atop the Helderberg Mountains.

By the use of the new relaying equipment, located 1.2 miles from the main transmitter atop the Helderberg Mountains, 12 miles from Schenectady, television broadcasts from New York City will become available to Capital District residents within the range of the company's W2XB station.

The programs transmitted from New York City are received at the relay station on the 44–50 megacycle band by means of a rhombic antenna that resembles two diamonds placed end to end and supported by four 128-foot towers. The programs then pass through an amplifier, a part of the antenna structure, that increases the signal strength about 20 times before entering a wire line leading to the relay receiving station located beneath the antenna.

## *Meetings*

AMERICAN SOCIETY OF TOOL ENGINEERS—Annual meeting, New York, N. Y., March 7–9. Ford R. Lamb, secretary, 2567 W. Grand Blvd., Detroit, Mich.

SOCIETY OF AUTOMOTIVE ENGINEERS—National aeronautic meeting, Washington Hotel, Washington, D. C., March 14–15. John A. C. Warner, secretary, 29 W. 39th St., New York, N. Y.

AMERICAN FOUNDRYMEN'S ASSOCIATION—Annual meeting, Palmer House, Chicago, Ill., May 3–10. C. E. Hoyt, vice president, 222 W. Adams St., Chicago.

# *Case Histories In Patent Law*

H. A. TOULMIN, JR.

(EDITOR'S NOTE: *We wish to emphasize that in consenting to furnish this column wherein general explanations of the law in specific patent cases are set forth, Col. H. A. Toulmin, Jr., wants it clearly understood "that each actual case should be submitted to your own patent attorney who is the only one familiar enough to advise you accurately." The purpose of these explanations is to give a better general understanding of questions of patent law*).

No. 15

QUESTION: What is a preliminary examination to determine patentability?

ANSWER: It is customary, where the inventor or the company owning the invention is not fully familiar with the new art in which he has made what seems to be a discovery that is patentable, to look up the prior patents that may exist in the United States Patent Office. In some cases both the United States and those foreign patents which are most likely to be cited by the Examiner to defeat the patent application in case it is filed are examined. This search is a wise precaution because it may save a great deal of expense and labor, not only in research and development work, but also in the cost of patent applications. It is better to know at an early date that the invention is not patentable than to go forward making investments and later learn that no patent will be granted.

The United States Patent Office is divided into some fifty divisions, each division handling a certain part of the industrial classes. For instance, one division handles electrical generation apparatus, such as galvonometers, inductoriums, meters, pyromagneto-electric devices, regulators, systems of distribution, magneto-electric devices, and so forth.

Each of these divisions is in charge of a Primary Examiner and an assistant. There is also a classification division for classifying patents in various classes according to the particular art to which this patent falls. It is, therefore, possible for a skilled searcher to look for the most likely patent that will anticipate invention. Oftentimes the Examiners are willing to indicate pertinent art in the particular field in which the man is searching. It is to the interest of both the Examiners and the Patent Office to prevent the filing of unwanted applications that can only result in expense and failure and an unnecessary amount of labor on the part of the government officials.

Some of the typical classifications in which patents are found are these: aeronautics; coin handling, such as registers; tools, automatic temperature and humidity regulation; classifying, separating and assorting solids; textiles, plastics; metal working; internal combustion engines, gas and liquid contact apparatus; electricity; chemistry; electrochemistry; explosives; harrows and diggers; land vehicles; ventilation; plows; optics; lubrication; laundry; hydraulic and earth engineering; horology; surgery; valves; and so forth.

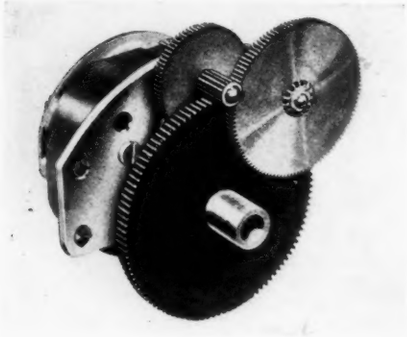
After this preliminary examination or rapid survey of the art has been made, it is possible to fairly indicate, although not guarantee, that the invention is sufficiently new and patentable to make it worth while to file the patent application. This is not to be confused with the thorough and exhaustive study of the state of the art, which takes many days, highly skilled investigators, and a complete and thorough knowledge of the field being investigated in order to be sure that all the patents, both United States and foreign, and the pertinent literature are secured.

Then, too, it is very useful upon occasion to call the attention of the Patent Office to the most pertinent art, so that it will be of record during the prosecution of the application. In this way, the art itself will have been discussed and passed upon by the Patent Office, so that at a later date in the event of suit, the fact that the prior art has been considered will be valued by the Court.

# New Materials and Parts

### *Shaded Pole Induction Motors*

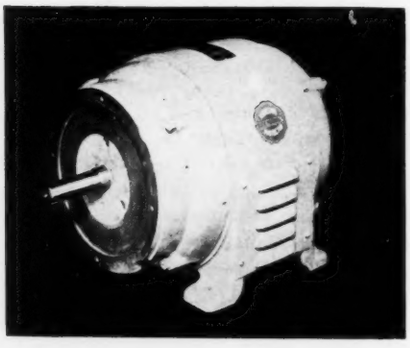
Line of open-type gear-reducing motors which are silent and brushless, designed for severe running conditions and long life, has been announced. These motors are built in three gear ratio sizes,



providing output shaft speeds of 80, 54 and 11 r.p.m. Several different outputs are provided for each speed, depending on the size and duty cycle of the motor employed. Cut spur gears are used in these reductions. A Textolite gear is provided on the first step to reduce noise to a minimum. The steel gears are cadmium-plated to resist corrosion. The gear studs and output shaft are nitrided to secure a hard non-corrosive bearing surface. The rotor shaft is hardened stainless steel. The gear plate is made of brass and is provided with holes for mounting to a suitable bracket. Barber-Colman Co., Rockford, Ill.

### *Motor End Shields*

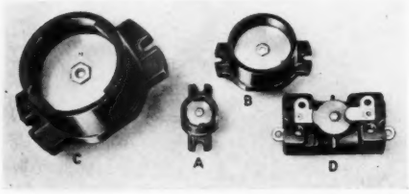
End shields having a flat surface to facilitate the mounting of pumps and other directly driven equipment and for



mounting magnetic brakes, are now available for U. S. Electrical motors. They can be assembled on either end of the motor and can be used to mount a footless motor to a machine frame if desired. The unimount end shields can be obtained in a number of standardized outside diameters, mounting machine fits, and bolt circles. They are also available unmachined so that the user can machine the mounting to suit his particular unit. U. S. Electrical Motors, Inc., Dept. 112, 80-30th St., Brooklyn, N. Y.

### *Motor Protectors*

When built into a motor automatically cut the motor out of line the instant dangerous temperatures are reached




within the motor. Yet they do not in any way limit the safe peak operation of the motor. Being automatic, they are recommended for unattended motors which are subjected to varying loads such as those used in air-conditioning equipment, stokers, circulators, blowers and oil burners. These over-heat and over-load protectors are designed for single and polyphase a.c. motors. Made in three sizes; ½ in. for single-phase motors up to ¼ hp., 1 in. for single-phase motors up to 1½ hp., and 1½ in. for protection of single and polyphase motors up to and including 3 hp. A two-pole protector is also available for certain types of fractional hp. repulsion-start induction and capacitor motors. Spencer Thermostat Co., 34 Forest St., Attleboro, Mass.

### *Die Cast Housing for Micro Switches*

Compact streamlined housings of die cast metal are now available with either open or closed top for Micro Switches. The bottom plate is removable for making connections. Terminals will accommodate No. 14 solid wire. No sealing or pigtails are employed. The hub takes

a standard ½ in. conduit, wires are brought directly into the switch. All electrical characteristics, movement and pressure differentials are maintained. Micro Switch Corp., Freeport, Ill.

### *Multi-BreakeR*

Breaker is trip free and cannot be held closed on a short circuit or overload. Indicating handle shows whether the breaker is on, off or tripped. Breakers are tamper proof, factory calibrated and sealed so that the intended capacity can-

not be exceeded. The breaker is available for flush or surface mounting. The breaker which is known as the Type M2 Multi-breakeR is of the two-pole, 100 amp. frame. An overload on one pole automatically trips both poles simul-

taneously. The breaker is designed for three-wire solid neutral, 115/230 volts, a.c., insulated groundable neutral, or two-pole, 115/230 volts, a.c., no neutral, in capacities of 50, 70, 90 and 100 amp. Square D Co., Detroit, Mich.

## *Self-Locking Nuts*

Nine new types of nuts, all of which embody the basic Elastic Stop self-locking non-metallic collar which is built into the head of the nut, have recently been placed on the market. The resilient collar, in resisting the entrance of the bolt or screw, forces the thread faces into a pressure contact which is maintained after the nut is tightened. With thread play thus eliminated, the nut cannot work loose under vibration, operating stresses, or wear of surrounding

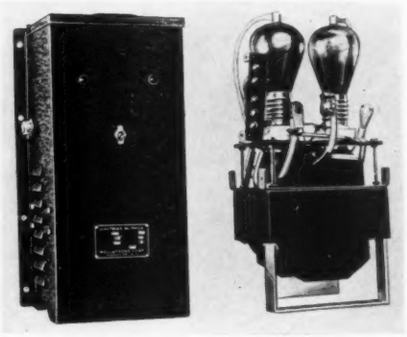
parts. The new types are: thin hexagonal, spline, internal wrenching, countersunk and counterbored one-lug anchor, countersunk and counterbored two-lug anchor, countersunk corner anchor, bracket anchor, floating right-angle anchor, and floating basket anchor. Elastic Stop Nut Corp., 1015 Newark Ave., Elizabeth, N. J.

## *Synthetic Coating for Conveyor Belts*

New synthetic coating for conveyor belting has been developed which, on the basis of tests, indicates that it will reduce the effects of aging. The coating was developed to prevent the deterioration from the effects of sunlight and air that takes place in conveyor belting when in storage or when it is idle for a considerable period. It is claimed that samples of conveyor belting under tension which were coated with this composition after exposure for six months to all varieties of weather, did not show any evidences of cover deterioration. The product is known as Goodrich R-60-T protective coating for conveyor belting. The B. F. Goodrich Co., Akron, Ohio.

## *Small Universal Rectifier*

Two mercury vapor type tubes are used to rectify full wave single phase a.c. Internal construction of the tubes is designed to prevent the filaments from sagging, and to promote long tube life. The rectifier contains no moving parts hence no maintenance is required. A.c. and d.c.



connections are made on a terminal board inside the hinged cover. An "off-on" switch is provided; red and green jeweled pilot lamps indicate when the current is "on". Compact in size, this rectifier has a d.c. output of 660 watts. It will withstand a 100 per cent overload for 5 min., thus making an ideal source of d.c. for motor operation where starting current is high. Size, 7½x5½x16½ in.; weight 26 lb. Mellaphone Corp., Rochester, N. Y.

## *Selectro-Plater*

Constructed so it may be stood on end, laid down or hung on wall. To plate, the worker plugs into the a.c. outlet and connects the cathode and anode

leads to the binding posts. A single knob variable control on the panel, enables the plater to adjust the voltage. Delivers 7½ volts at 4 amp. on continuous load and over 8 amp. on intermittent loads or flash plating. It operates on a.c. at line voltages of 105, 110 and 125 volts. The unit is designed for jewelers, small plating plants and experimental laboratories. This small power plant is a complete unit with dimensions approx. 10x6x5 in. and weighs about 10 lb. W. Green Electric Co., 192 Broadway, New York, N. Y.

## *Chromium and Nickel Bonded Aluminum*

Two new prefinished bonded metals which combine the beauty and durability of nickel and chromium with the lightness, strength and workability of aluminum are formed by an electrolytic process using the Krome Alume process patent. Because the aluminum does not have to be etched to secure a bond, the luster of the plated surface is not dulled. The illustration shows a decorative plate made from the material. Available in sheets and sizes up

to 36x96 in. in a full range of tempers, and gauges from 0.010 up to 0.064 in., with a choice of bright or satin finish and striped, crimped, or corrugated patterns. Both metals are highly resistant to corrosion, rust or tarnish. American Nickeloid Co., Peru, Ill.

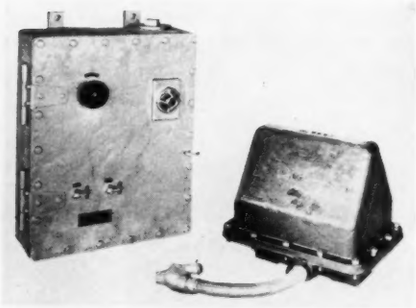
## *Contact Materials*

The alloying elements are such as to create a de-ionization action in the medium between the arcing contact tips. This de-ionization action tends to quickly quench the arc, resulting in the elimination of arcing dangerous to circuit equipment and detrimental to the contact life. Also, the characteristics are such as to render the contact faces self-cleaning

with the attendant arcing, which action results in a low contact resistance value. The material is said to be non-sticking in operation and will not fuse under heavy overloads. Known as Mallory 8CC metal, the material is a copper base alloy having electrical conductivity 50 to 60 per cent that of copper, hardness 50 to 55 Rockwell B. This alloy cannot be hot or cold worked and is supplied only in the form of sand castings. The metal is free cutting and machines readily. P. R. Mallory & Co., Inc., Indianapolis, Ind.

## *Vibrators and Controllers*

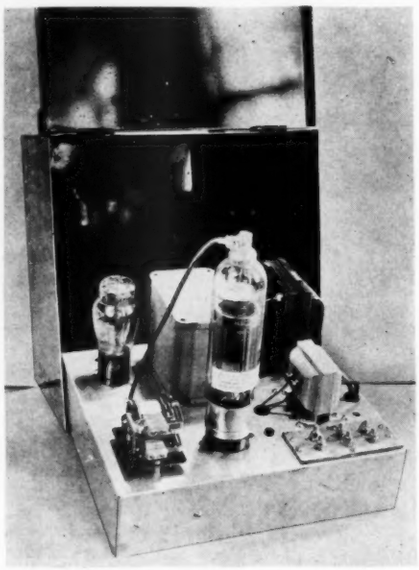
Explosion proof types for use in oil refineries, chemical plants, paint works and flour mills, where atmospheric conditions are highly inflammable or explosive. The vibrator, a heavy pulsating electro-magnet, is fully incased in a thick electric-furnace steel case with ground joints, with an armored cable



lead. The remote control panel contains a rectifier, operating switches and rheostat for controlling the vibrator; this is fully incased in a cast iron case with ground joints and approved explosion proof fittings. The vibrators are used for attachment to bins, hoppers and chutes, to prevent arching over and hanging up of material, and to insure a free flow at all times. The Syntron Co., 240 Lexington Ave., Homer City, Pa.

## *Automatic Welding Timer*

Electronic timer for automatically controlling welding of small parts or thin materials where it is important that the welding time be strictly limited to a matter of a few milliseconds. Timer is designed to be used with materials where the weld comes up to temperature almost instantly and the continued application of current beyond this time only serves to heat the electrode and increase the tendency for the work to stick. Timer functions by allowing current to flow for each weld only for the full duration of a single half-cycle of the 60-cycle supply, and by blocking further current flow until the manually operated switch at the welder is again tripped for the next weld. The control action is entirely electronic. The unit is housed in a standard switch box with the knock-outs pro-



viding ample ventilation. Compact size simplifies installation and the characteristics are such as to make the unit positive and foolproof in operation. Callite Products Co., Div. Eisler Electric Corp., Union City, N. J.

## *Cold Tinning Compound*

For use in spraying onto aluminum. It is claimed that this new compound does away with special aluminum solders and fluxes. The surface to be tinned is prepared in the usual way. A clean rag moistened with water is then dipped into the compound and rubbed over the surface to be tinned until a shiny metal coating is formed. This coating then forms a permanent bond with a tin-lead solder which is sprayed on later. Glaser Lead Co., Inc., 31 Wyckoff Ave., Brooklyn, N. Y.

## *Vulcalock Cements*

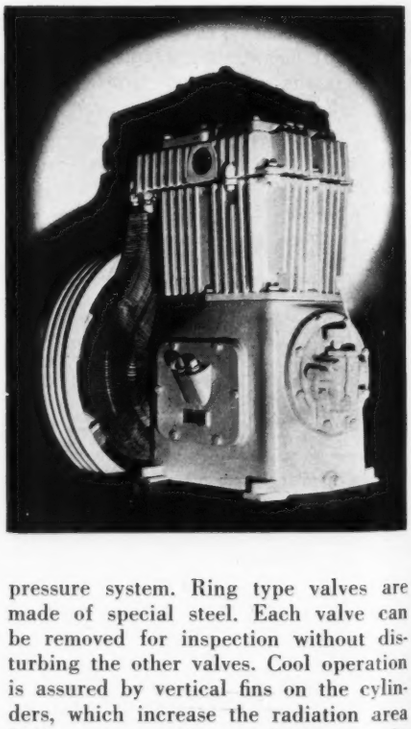
Vulcalock cements, which have unique properties in joining a wide variety of materials, particularly in making strong, waterproof, chemically resistant joints between rubber and metal, have now been released for sale on a restricted basis. The cements are not rubber, but are solutions of Thermoprene, a patented thermoplastic made by chemical alteration of rubber. They are translucent, amber liquids of light engine oil consistency, and when dried they form a tough, horny film. Strength of bond ranges from 10 to 500 lb. per sq.in., depending upon methods of application and materials joined. The cement resists cracking by bending, shock, or variations in temperature, have chemical resistance better than rubber itself, and do not absorb moisture nor swell in water. B. F. Goodrich Co., Akron, Ohio.

## *Synthetic Wax*

Made from domestic raw materials, has been introduced under the name of Acrawax C. This product has a melting point of 133-134 deg. C. and yet is not hard nor brittle. It is insoluble in water. It is soluble in hot mineral spirits, turpentine, toluol, naphtha and similar hydrocarbon solvents. Solutions in turpentine, naphtha and toluol produce a stable gel on cooling. Acrawax C blends with paraffine, carnauba wax, candelilla wax, and rosin. Glyco Products Co., Inc., 148 Lafayette St., New York, N. Y.

## *Pressure Lubricated Air Compressors*

Lubrication under pressure is furnished by a gear type pump to connecting rod bearings and piston pins. Oil pump is mounted on the end of crankshaft, which is of special 1045 S.A.E. heat-treated steel. Main bearings are Timkens, lubricated by a splash system which functions separately from the



pressure system. Ring type valves are made of special steel. Each valve can be removed for inspection without disturbing the other valves. Cool operation is assured by vertical fins on the cylinders, which increase the radiation area 12½ per cent and over which air is directed by a combination fan and flywheel. These new compressors, Models 244 and

340 are designed for heavy duty industrial use. Model 244 is a duplex cylinder, single stage compressor having 40 cu.ft. per min. maximum displacement. The two-stage model has a large copper fin in the cooler to secure maximum temperature drops between the low and high pressure cylinders. Quincy Compressor Co., Quincy, Ill.

## *Drafting Chair*

Designed especially for use with Auto-Shift tables, this chair is of ordinary desk height and is comfortably padded with an adjustable back rest so that it can be set for proper posture of the draftsman. The chair is of the swivel type and is mounted on rubber casters. The

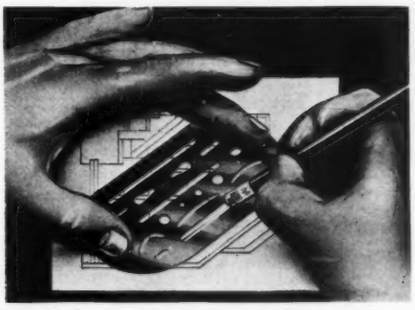
chair is finished in olive green to match the usual drafting furniture and office equipment. Hamilton Mfg. Co., Two Rivers, Wis.

## *Cuferco*

A new alloy resembling Cupaloy has been announced. Cuferco has three components: copper, iron and cobalt. The iron-cobalt content is highly important in determining the characteristics of the alloy. For best composition, identical quantities of the two elements are used, the normal proportions being about 96 per cent copper and 2 per cent of iron and cobalt. Electrical conductivity of the alloy is about 70 per cent as good as that of copper, and has about the same tensile strength as hot-rolled low-carbon machinery steel. Because of its iron content, this alloy can be hardened by heat-treating. Cuferco is softened very little by repeated applications of heat. It is expected that it will be suitable for tips of spot welders. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

## *Skid-Proof Erasing Shield*

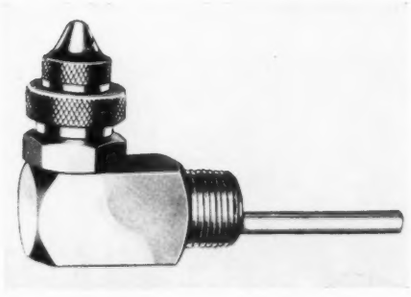
Non-skid erasing shield is provided with cupped openings for finger and thumb in order to grip the shield firmly to the paper and to prevent the shield



from slipping. The shield is designed to put an end to troubles encountered with slippery type shields. Made of high-grade flexible safety razor steel, $2\frac{3}{8}$x$4\frac{3}{8}$ in., has 14 openings. Eugene Dietzen Co., 2425 Sheffield Ave., Chicago, Ill.

## *Pneumatic Atomizing Nozzle*

For chemical processes and humidifying in industrial processes where a constant proportion is to be maintained for intermittent spraying. The nozzle is avail-



able with internally mixed round or flat spray. It is screwed directly into a pipe where the liquid is maintained at a constant level. The same pipe serves as an air supply header. Standard stock construction is brass; other metals can be specified. Spraying Systems Co., 4011-21 W. Lake St., Chicago, Ill.

## *Silver Stainless Steel*

The inclusion of silver in quantities of less than 1 per cent, has rendered a new 18–8 stainless steel substantially immune to pit corrosion, a type of corrosion which ordinary 18–8 stainless encounters in contact with salt water. Another benefit claimed for the addition of the silver is a decided reduction in work hardening of the austenitic chromium-nickel stainless steel. The new alloy can be cast, rolled, drawn and forged, and is said to be especially suitable for drawing or spinning. This unusual steel was developed at the Massachusetts Institute of Technology. Products have been fabricated by the Lebanon Steel Foundry Co., and Eastern Rolling Mills. The Chemical Foundation, Inc., 654 Madison Ave., New York, N. Y.

## *Corrosion-Resistant Alloy Sheet*

Plates weighing up to 100 lb. each can now be made of a corrosion-resistant nickel-molybdenum-chromium-iron alloy known as Hastelloy Alloy C. This alloy effectively withstands strong oxidizing agents such as acid solutions of ferric or cupric salts, and aqueous solutions containing chlorine or hypochlorites. The material also has good resistance to hydrochloric acid up to 50 deg. C. and to sulphuric acid at temperatures up to 70 deg. C. if the concentration is over 50 per cent, or up to boiling if the concentration is under 50 per cent. In rolled form, the alloy has a tensile strength in excess of 75,000 lb. per sq.in. and also an elongation and reduction of area of approximately 15 per cent. Haynes Stellite Co., Kokomo, Ind.

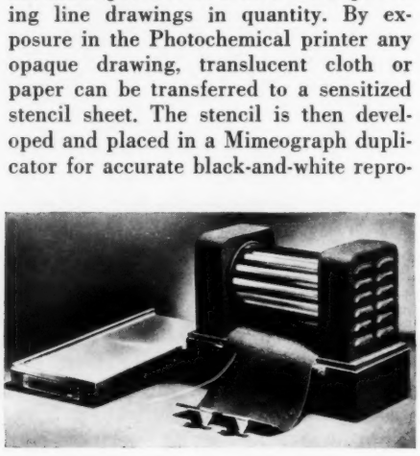
## *Air Control Valve*

Of the heavy duty type, has poppet type valve. Mounting flange, lever and other parts are designed for heavy service. Special alloy lever and rocker-arm pins are fitted with needle type roller bearings. Large stuffing boxes are a feature, poppet stems and retainers are stainless steel. Mounting dimensions, pipe

connection locations and bolt holes remain the same as in the standard size. Ross Operating Valve Co., 6493 Epworth Blvd., Detroit, Mich.

## *Photochemical Printer*

Development of a strong light source has made possible a method for duplicating line drawings in quantity. By exposure in the Photochemical printer any opaque drawing, translucent cloth or paper can be transferred to a sensitized stencil sheet. The stencil is then developed and placed in a Mimeograph duplicator for accurate black-and-white reproduction in quantity. Time of procedure from finished tracing to finished copies is generally less than 25 minutes. Included in the assembly are the portable printer, developing plate, and all necessary accessories except chemicals and stencil sheets. A. B. Dick Co., 722 W. Jackson Blvd., Chicago, Ill.



## *Ethyl Polychlorobenzene*

Ethyl polychlorobenzene, a highly stable liquid, has just been announced for application as a heat transfer fluid, dielectric for electric condensers, fluid for pressure control mechanisms, and non-inflammable lubricant. The material is described as having excellent electrical properties. It can be boiled with aqueous solutions, including 20 per cent caustic soda or 20 per cent sulphuric acid, without appreciable change. Heating with iron, aluminum or copper at 200 deg. C., produces no change or corrosion of the metals. It sludges and darkens on long and continued refluxing at elevated temperatures in contact with iron, with a slight generation of hydrochloric acid. It is less affected by copper and still less by aluminum. E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

## *New Molding Compound*

An easily preformed phenolic molding material has been announced which is claimed to deliver an unusually smooth finish for a standard high-impact type. The preforming properties are the result of the particle size and shape. The particle size is controlled so that the material will flow through hoppers and automatic feeding devices readily. This material is known as Durez 1900 Black. Durez Plastic & Chemicals, Inc., North Tonawanda, N. Y.

## *Hard-Facing Rod*

Recommended for use where severe abrasion accompanied by only a moderate amount of impact is encountered, a new alloy welding rod for hard surfacing wearing parts has just been announced. The new rod, known as Haynes "93" does not possess as high wear resistance as Haystellite cast tungsten carbide products or Haynes Stellite alloys. It is, on the other hand, more wear-resistant, but not as tough as Hascrome hard-facing alloy. The rod is of a ferrous composition and contains chromium, molybdenum, cobalt, and other alloying elements to the extent of more than 40 per cent. It has a tensile strength of about 43,000 lb. per sq. in. and a hardness, as-deposited by oxy-acetylene welding, of 62 Rockwell C. When deposits are heat-treated by heating to 1,950 deg. F. and then air-cooled, the hardness reaches 66 to 67 Rockwell C. Haynes Stellite Co., Kokomo, Ind.

## *Aridifier*

For removing dirt, scale, oil and moisture from compressed air and gas lines. Foreign matter impinges on a number of "propeller blades," which revolve in opposite directions, and which are propelled by the flow of air or gas. The arrested contamination and moisture is collected in the lower housing from where it is drawn off as occasion warrants. These units are designed for application to lines supplying compressed air to spray booths and other manual and automatic spraying and finishing operations. Removal of extraneous foreign matter provides clean air for finer finishes. Units are made in $\frac{3}{8}$ in to 10 in. standard pipe sizes. Logan Engineering Co., 4912 Lawrence Ave., Chicago, Ill.

## *Marking Device*

Designed to mark parts having annular flat faces, such as gears, bushings and bearing races. The holder in which the type retainers are carried, is provided with a pilot guide to center the marking device. Type retainers are carried in the holder in T-slots. The type retainers are provided with elongated slots on their inner faces, into which balls are fitted and held under spring pressure so that the retainers cannot drop out of the holder, but can be removed by a sharp pull. Type holders may be used for either solid type blocks or individual type, set screws lock the type in place. New Method Steel Stamps, Inc., 143 Campau St., Detroit, Mich.

## *Stainless Steel Electrode*

For arc welding stainless steel of the 25 per cent chromium, 20 per cent nickel type, such as is specified by the Iron and Steel Institute as No. 310, a stainless steel known as "Stainweld D" has been announced. The electrode is also used for welding various stainless steels to mild steel and for welding of air hardening steels which cannot be heat-treated after welding, such as armor plate and similar steels. In general, preparation of the work and welding procedure is similar to that used in mild steel welding. The surfaces to be welded should be free from all foreign material. Slag should be thoroughly cleaned. Thin sheets should be clamped against a copper backing to maintain alignment, to reduce buckling and prevent burning through. These electrodes, $11\frac{1}{2}$ in. in length, and packed in 25-lb. containers and are available in sizes $\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$ and $\frac{1}{4}$ in. in diam. The Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio.

# Manufacturers' Publications

## Materials

BEARINGS—Bound Brook Oil-less Bearing Co., Bound Brook, N. J. Catalog page 8½x11 in., describes features of and applications for graphited bronze bearings with notes covering permissible loads, dimensions and tolerances, also method of installation.

FRICTION MATERIAL—The S. K. Wellman Co., 1381 E. 49th St., Cleveland, Ohio. Bulletin, 4 pages, 8½x11 in. Information covering the construction and composition of Velvetouch Bimetallic Friction Material, forms available with working properties and characteristics. Applications in industrial, aviation and automotive fields are listed.

ZINC ALLOY—The New Jersey Zinc Co., 160 Front St., New York, N. Y. "Zinc Alloy Die Castings in Small Tools," 3⅞x7½ in. Illustrates many examples of the application of zinc alloy die castings to parts for small tools of all kinds.

## Mechanical Parts

BALL BEARINGS—New Departure Division General Motors Sales Corp., Bristol, Conn. This company announces publication of the 1940 edition of their ball bearing interchangeability tables in booklet form.

BALL BEARINGS—Nice Ball Bearing Co., 30th and Nicetown Lane, Philadelphia, Pa. Catalog No. 110, 70 pages, 4⅜x7½ in. Descriptive matter showing applications and dimensions covering radial ball bearings, thrust ball bearings, combination type ball bearings, ball retainers, casters, ball bearing sheaves, ball bearing wheels, and specifications for steel, bronze and stainless balls.

BRONZE CHAINS—Link-Belt Company, 307 N. Michigan Ave., Chicago, Ill. Folder 1804, 4 pages, 6x9 in. Suggested applications of Link-Belt bronze detachable and pintle chains with a check list showing the correct bronze composition to use.

DUST CAPS—Gits Bros. Mfg. Co., 1846-62 S. Kilbourn Ave., Chicago, Ill. This circular describes self-closing dust caps for installation on pneumatic couplings, fuel tanks, and similar applications.

FLEXIBLE COUPLINGS—Charles Bond Co., 617-623 Arch St., Philadelphia, Pa. Catalog TF-16, 12 pages, 3½x6 in. Condensed catalog showing five different types of flexible insulated couplings with illustrations, tables of dimensions and horsepower ratings.

METAL BELLOWS—The Fulton Sylphon Co., Knoxville, Tenn., folder SF-511, four pages, 8½x11 in. Describes seamless metal bellows and uses as diaphragms for converting pressure effects into controlled motion, expansion chambers and similar services. Ordering specifications are listed.

OIL FILM BEARING—Koppers Co., Bartlett Hayward Division, Baltimore, Md., has announced a booklet describing new Fast's Multiple Oil Film Bearing, describing and illustrating the design, with tables of dimensions and load capacities, bearing housings, recommended shaft sizes, dimensions of lock nuts and proper oil levels.

SCREWS, STUDS, AND BOLTS — Aircraft Screw Products Co., Inc., 25-12-41st Ave., Long Island City, N. Y. Bulletin T-1, 16 pages, 8½x11 in. This bulletin has been prepared to provide data on standard sizes, basic formulas, and engineering information required for the application of the Aero-Thread Screw Thread System. Dimensions and tolerances of standard Aero-Thread screw connections are listed, together with description of typical applications for this screw system.

SPEED REDUCERS—Janette Mfg. Co., Chicago, Ill. Bulletin 22-25C, 100 pages, 8½ x11 in. Illustrates, describes, and gives engineering data on complete line of Janette speed reducers.

STOP NUTS AND FITTINGS—Elastic Stop Nut Corp., 1001 Newark Ave., Elizabeth, N. J. 12 new pages, 8½x11 in., for insertion in the 1938–39 edition of the Elastic Stop Nut Catalog. These additional sheets list new items and some list changes in the earlier catalogs.

V-BELTS—B. F. Goodrich Co., Akron, Ohio. Catalog 2180, 24 pages, 8½x11 in. Five pages of this catalog section on fractional-horsepower V-belt design outline all the factors in selecting the proper drive.

VARIABLE SPEED PULLEYS—The Speedmaster Co., Des Plaines, Ill. Folder, 4 pages, 8½x11 in. Describes the advantages of variable speed installations, and lists construction and installation features of the Speedmaster line.

## Electrical Parts

SHADED POLE MOTORS—Barber-Colman Co., Rockford, Ill. Motor data sheet M-61, four pages, 8½x11 in. Specifications covering standard and special shaded pole induction motors describing construction and features. Tables of performance characteristics are presented for both the standard unidirectional motors and for the geared head motors.

D-C MOTORS—Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio. Bulletin 220, two pages, 8½x11 in. Information regarding construction details of Type T explosion-proof d.c. motors.

BATTERY CHARGER—General Electric Co., Schenectady, N. Y. Bulletin No. GEA-3179A, four pages, 8x10½ in. Describes the constructional features and the advantages of the CR7 501-K Phano-Charger for storage batteries. Charts show the characteristic data of this charger under load.

MOTORS AND CONTROLS—General Electric Co., Schenectady, N. Y. Publication GED-806, 12 pages, 9x12 in. Collection of some recent G-E advertisements, showing features and applications of G-E motor and controls.

## Fabrication Methods

AUTOMATIC MOLDING—F. J. Stokes Machine Co., Tabor Road, Philadelphia, Pa. 16-page booklet on automatic molding, combined with a catalog of automatic molding machines, showing several different models and describing how they operate to cut molding time, labor, and material.

SOLDERING AND TINNING—Glaser Lead Co., Inc., 31 Wyckoff Ave., Brooklyn, N. Y. Folder, 3½x6½ in. Describes types of solder to use for various kinds of work.

SPOT WELDERS—Pier Equipment Mfg. Co., Milton & Cross Sts., Benton Harbor, Mich. Catalog No. 40, 12 pages, 8½x11 in. Detailed information on various models of the Ace Spot Welders, an interesting discussion on the choice of manual and automatic types is also included.

SURFACE HARDENING—The Ohio Crankshaft Co., Cleveland, Ohio. Bulletin, 12 pages, 8½x11 in. A comprehensive explanation of the Tocco Process for surface hardening by induction. Diagrams and illustrations emphasize the points brought out in the text.

## Finishes

PROTECTING ALUMINUM—Pyrene Manufacturing Co., 560 Belmont Ave., Newark, N. J. Booklet, 8 pages, 5½x8½ in. Describes the Pylumin process for the protection of aluminum, as well as the installation and operation of the process. It also discusses use of the process as a corrosion-proof base for paint finishes, or for the protection of unfinished aluminum parts.

## Miscellaneous

CREEP STRESS DATA—The Babcock & Wilcox Tube Co., Beaver Falls, Pa. Technical Data Card No. 4. Relative creep stress data on Croloys 2 and 2¼ and other materials in the same range in the high temperature tubing field, arranged in the form of a chart so that the relative creep strength of each material can be seen at a glance.

ENGINEERING LITERATURE—Allis-Chalmers Mfg. Co., Milwaukee, Wis. Booklet, 36 pages, 6x8 in. Directory of Products & Engineering Literature, which lists in numerical order more than 350 separate bulletins and other engineering aids covering a widely diversified group of products made by this company.

INSTRUMENTS—Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa. Catalog E, 66 pages, 7⅝x10½ in. This condensed catalog describes and illustrates the complete Leeds & Northrup line of electrical measuring instruments for research, and testing.

# Books and Bulletins

## *The Construction of Nomographic Charts*

F. T. MAVIS—*132 pages, 5 x 8⅜ in. Flexible fabricoid covers. Published by International Textbook Co., Scranton, Pa. Price $2.*

This volume has been prepared for advanced undergraduate students and for engineers in professional practice. The introductory chapters review in detail the theory of logarithms, the slide rule, functional coordinate papers, and those phases of the theory of determinants and analysis which are necessary for the development of alinement charts.

Under the theory of nomographic charts the author analyses the geometrical significance of third order determinants and the method of writing equations in determinant form. Numerous examples are presented for the construction and direct solution of many types of equations commonly used in engineering calculations. The relations between nomographs and systems of straight lines, and the construction of nomographic charts from empirical curves are thoroughly discussed.

The subject matter is generously illustrated with tables and figures of graphs. A short selected bibliography is also included.

## *1939 A.S.T.M. Standards*

PART 2, NONMETALLIC MATERIALS—CONSTRUCTIONAL—*1,217 pages, 6 x 9 in. Clothboard covers. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Price $8.*

Triennial publications of A.S.T.M. Standards including Tentative Standards. This volume, Part 2, includes the respective tentative specifications and tests as well as those adopted as standard relating to cementitious materials, concrete, masonry building units, ceramics, pipe, timber and preservatives, paints, road materials, waterproofing materials, soils and general testing methods. The volume contains 350 specifications, of which 260 are standard and 90 are tentative.

PART 3, NONMETALLIC MATERIALS—GENERAL—*1,175 pages, 6 x 9 in. Clothboard covers. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Price $8.*

Triennial publication of A.S.T.M. Standards including Tentative Standards. This volume, Part 3, includes the respective tentative specifications and tests as well as those adopted as standard relating to fuels, petroleum products, electrical insulating materials, rubber, textiles, soaps and detergents, paper, plastics, water, general testing methods and thermometers. The volume contains 245 specifications, of which 130 are standard and 115 are tentative.

This latest edition incorporates many features such as double-column format, improved editorial style, amplified subject indexes. Two tables of contents list by subjects and by serial designations of standards.

## *Machine Design*

V. L. MALEEV—*579 pages, 6 x 9 in. Blue clothboard covers. Published by International Textbook Co., Scranton, Pa. Price $4.50.*

An attempt is made in this text to assemble the results of recent research data regarding stress distribution, stress concentration and endurance of materials as a basis of design, and by applications of this new data to design problems eliminate some of the inconsistencies which arise from assumptions that elastic deformations from working stresses in machine parts can be neglected.

The author has concentrated his attention on the most important problems and general machine parts. While the scope of the book covers the usual classifications found in treatises on machine design, the treatment and basic methods developed for design are in keeping with modern trends and refinements which seek efficiently to utilize materials to obtain light weight without sacrificing necessary strength to resist static and repeated dynamic loads. This view point is excellently indicated in the chapter on machine design calculations in the treatment of the safety factor for static loads as differentiated from the safety factor for dynamic loads.

## *Theory and Design of Springs*

FRED M. COUSINS—*100 pages, 8 x 10¾ in. Blue clothboard covers. Text is lithoprinted. Published by Edwards Brothers, Inc., Ann Arbor, Michigan. Price $2.50.*

The author presents analyses of the more general types of springs in a manner suited to meet the requirements of both engineering designers and academic students. In preparing the subject matter, the author has drawn from his own experience in the automotive industry.

Starting with a discussion of elastic vibrations of springs with equations for motion and oscillations, the author develops the general theories underlying the methods used to determine stresses and deflections produced by loading springs of the commonly used types such as; close coiled and open coiled helical springs, torsion and spiral springs, conical springs, valve springs, leaf springs and flat springs, ring springs and disk springs.

Line drawings are used throughout the book to supplement the mathematical treatment. Three pages of bibliography are appended for further reference and study.

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### *Evaluation of Petroleum Products*

*Booklet, 52 pages, 6 x 9 in. Paper covers. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Price 75 cents.*

Six papers reviewing the present status of the testing of petroleum products and lubricants. The titles of the papers and their authors are: "Lubricating Oils" by J. C. Geniesse, "Petroleum Lubricating Greases" by M. B. Chittick, "Gasoline" by T. A. Boyd, "Diesel Fuels" by T. B. Rendel, "Fuel Oils (Other Than Diesel)" by H. V. Hume, and "The Status of Research on Fuels and Lubricating Oils for Spark-Ignition Aircraft Engines" by S. D. Heron. References are included with each paper.

### *A Survey of the Science of Heat Transmission*

*Engineering Bulletin, Research Series No. 68, 60 pages, 6 x 9 in. Published by Purdue University Engineering Experiment Station, Lafayette, Ind. Price 25 cents.*

A series of three lectures presented by Dr. Max Jakob at Purdue University. The topics for the lectures are: Fundamental Laws of Heat Transmission; Decisive Properties of Matter; and Typical Methods. The lectures deal with heat transmission in its threefold manifestation as heat conduction, heat convection, and heat radiation; also the laws forming the basis of the science, the characteristic properties of matter which comprise the constants or variables, and methods for solving the fundamental equations or how to avoid the solution if it presents insurmountable difficulties.

### *Stainless-Clad Steel*

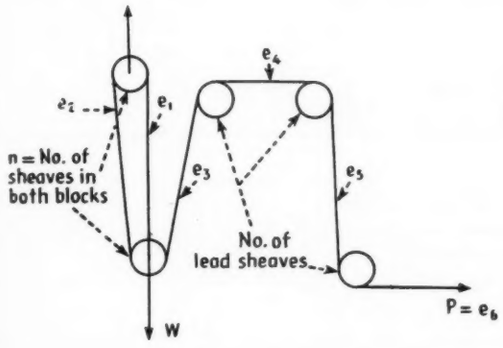
*Bulletin, 24 pages, 8½ x 11 in. Published by Jessop Steel Co., Washington, Pa.*

Bulletin contains useful engineering information on the manufacture, fabrication, and the chemical and physical properties of Jessop Silver-Ply stainless-clad steel. Industries using this material are listed as well as varied types of fabricated equipment. Subject matter is supplemented with halftones and line drawings.

# WIRE ROPE TACKLE BLOCKS

## *Ratio of Lead Pull to Load When Lifting*

A. C. RASMUSSEN
*Chief Engineer, Insley Manufacturing Company*




With force P pulling to lift load blocks are drawn toward each other and

$e_5 = e_6 c = Pc$
$e_4 = e_5 c = Pc^2$
$e_3 = e_4 c = Pc^3$
$e_2 = e_3 c = Pc^4$
$e_1 = e_2 c = Pc^5$

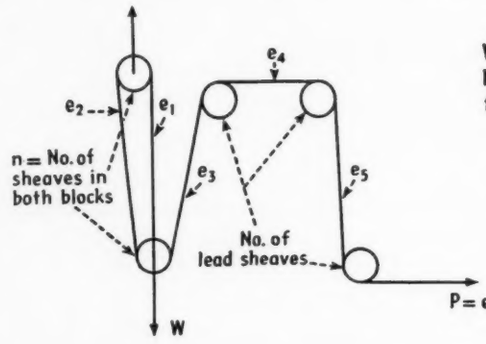
Since $W = e_3 + e_2 + e_1$
or $W = Pc^3 + Pc^4 + Pc^5$
$= Pc^3 (1 + c + c^2)$
In general $W = P[c^m (1 + c + c^2 + \_\_\_ + c^n)] = PK$

### Values of $K$ for Various Values of $m$ and $n$

| No. of Parts Line | $n$ No. of Block Sheaves | No. of Lead Sheaves $= m$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | $c^n$ For $c = 0.94$ |
| 1 | 0 | 1.0000 | 0.9400 | 0.8836 | 0.8306 | 0.7807 | 0.7339 | 0.6899 | 1.0000 |
| 2 | 1 | 1.9400 | 1.8236 | 1.7142 | 1.6113 | 1.5146 | 1.4238 | 1.3384 | 0.9400 |
| 3 | 2 | 2.8236 | 2.6542 | 2.4949 | 2.3452 | 2.2045 | 2.0723 | 1.9480 | 0.8836 |
| 4 | 3 | 3.6542 | 3.4349 | 3.2288 | 3.0351 | 2.8530 | 2.6819 | 2.5210 | 0.8306 |
| 5 | 4 | 4.4349 | 4.1688 | 3.9187 | 3.6836 | 3.4626 | 3.2549 | 3.0596 | 0.7807 |
| 6 | 5 | 5.1688 | 4.8587 | 4.5672 | 4.2932 | 4.0356 | 3.7935 | 3.5659 | 0.7339 |
| 7 | 6 | 5.8587 | 5.5072 | 5.1768 | 4.8662 | 4.5742 | 4.2998 | 4.0418 | 0.6899 |
| 8 | 7 | 6.5072 | 6.1168 | 5.7498 | 5.4048 | 5.0805 | 4.7757 | 4.4892 | 0.6485 |
| 9 | 8 | 7.1168 | 6.6898 | 6.2884 | 5.9111 | 5.5564 | 5.2231 | 4.9097 | 0.6096 |
| 10 | 9 | 7.6898 | 7.2284 | 6.7947 | 6.3870 | 6.0038 | 5.6436 | 5.3050 | 0.5730 |
| 11 | 10 | 8.2284 | 7.7347 | 7.2706 | 6.8344 | 6.4243 | 6.0389 | 5.6766 | 0.5386 |
| 12 | 11 | 8.7347 | 8.2106 | 7.7180 | 7.2549 | 6.8196 | 6.4105 | 6.0259 | 0.5063 |
| 13 | 12 | 9.2106 | 8.6580 | 8.1385 | 7.6502 | 7.1912 | 6.7598 | 6.3542 | 0.4759 |
| 14 | 13 | 9.6580 | 9.0785 | 8.5338 | 8.0218 | 7.5405 | 7.0881 | 6.6628 | 0.4474 |
| 15 | 14 | 10.0785 | 9.4738 | 8.9054 | 8.3711 | 7.8688 | 7.3967 | 6.9529 | 0.4205 |
| 16 | 15 | 10.4738 | 9.8454 | 9.2547 | 8.6994 | 8.1774 | 7.6868 | 7.2256 | 0.3953 |
| 17 | 16 | 10.8454 | 10.1947 | 9.5830 | 9.0080 | 8.4675 | 7.9595 | 7.4819 | 0.3716 |
| 18 | 17 | 11.1947 | 10.5230 | 9.8916 | 9.2981 | 8.7402 | 8.2158 | 7.7229 | 0.3493 |
| 19 | 18 | 11.5230 | 10.8316 | 10.1817 | 9.5708 | 8.9965 | 8.4568 | 7.9494 | 0.3283 |
| 20 | 19 | 11.8316 | 11.1217 | 10.4544 | 9.8271 | 9.2375 | 8.6833 | 8.1623 | 0.3086 |
| 21 | 20 | 12.1217 | 11.3944 | 10.7107 | 10.0681 | 9.4640 | 8.8962 | 8.3624 | 0.2901 |
| 22 | 21 | 12.3944 | 11.6507 | 10.9517 | 10.2946 | 9.6769 | 9.0963 | 8.5505 | 0.2727 |
| 23 | 22 | 12.6507 | 11.8917 | 11.1782 | 10.5075 | 9.8770 | 9.2844 | 8.7273 | 0.2563 |
| 24 | 23 | 12.8917 | 12.1182 | 11.3911 | 10.7076 | 10.0651 | 9.4612 | 8.8935 | 0.2410 |
| 25 | 24 | 13.1182 | 12.3311 | 11.5912 | 10.8957 | 10.2419 | 9.6274 | 9.0498 | 0.2255 |
| 26 | 25 | 13.3311 | 12.5312 | 11.7793 | 11.0725 | 10.4081 | 9.7837 | ..... | 0.2129 |
| 27 | 26 | 13.5312 | 12.7193 | 11.9561 | 11.2387 | 10.5644 | ..... | ..... | 0.2001 |
| 28 | 27 | 13.7193 | 12.8961 | 12.1223 | 11.3950 | ..... | ..... | ..... | 0.1881 |
| 29 | 28 | 13.8961 | 13.0623 | 12.2786 | ..... | ..... | ..... | ..... | 0.1768 |
| 30 | 29 | 14.0623 | 13.2186 | ..... | ..... | ..... | ..... | ..... | 0.1662 |

# WIRE ROPE TACKLE BLOCKS

## *Ratio of Lead Retarding Force to Load When Lowering*




With force P retarding to lower load blocks move away from each other and

$e_5 = e_6/c = P/c$
$e_4 = e_5/c = P/c^2$
$e_3 = e_4/c = P/c^3$
$e_2 = e_3/c = P/c^4$
$e_1 = e_2/c = P/c^5$

Since $W = e_1 + e_2 + e_3$
or $W = P/c^5 + P/c^4 + P/c^3$
$= (P/c^3)(1/c^2 + 1/c + 1)$
$= (P/c^3)[(1 + c + c^2)/c^2]$
In general $W = (P/c^m)[(1 + c + \cdots + c^n)/c^n] = PK'$

### Values of $K'$ for Various Values of $m$ and $n$

| No. of Parts Line | $n$ No. of Block Sheaves | No. of Lead Sheaves $= m$ | | | | | | | $1/c^n$ For $c = 0.94$ |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | |
| 1 | 0 | 1.0000 | 1.0638 | 1.1317 | 1.2040 | 1.2808 | 1.3626 | 1.4496 | 1.0000 |
| 2 | 1 | 2.0638 | 2.1955 | 2.3357 | 2.4848 | 2.6434 | 2.8122 | 2.9917 | 1.0638 |
| 3 | 2 | 3.1955 | 3.3995 | 3.6165 | 3.8474 | 4.0930 | 4.3543 | 4.6322 | 1.1317 |
| 4 | 3 | 4.3995 | 4.6803 | 4.9791 | 5.2970 | 5.6351 | 5.9948 | 6.3774 | 1.2040 |
| 5 | 4 | 5.6803 | 6.0429 | 6.4287 | 6.8391 | 7.2756 | 7.7400 | 8.2340 | 1.2808 |
| 6 | 5 | 7.0429 | 7.4925 | 7.9708 | 8.4796 | 9.0208 | 9.5966 | 10.2091 | 1.3626 |
| 7 | 6 | 8.4925 | 9.0346 | 9.6113 | 10.2248 | 10.8774 | 11.5717 | 12.3103 | 1.4496 |
| 8 | 7 | 10.0346 | 10.6751 | 11.3565 | 12.0814 | 12.8525 | 13.6729 | 14.5456 | 1.5421 |
| 9 | 8 | 11.6751 | 12.4203 | 13.2131 | 14.0565 | 14.9537 | 15.9082 | 16.9236 | 1.6405 |
| 10 | 9 | 13.4203 | 14.2769 | 15.1882 | 16.1577 | 17.1890 | 18.2862 | 19.4534 | 1.7452 |
| 11 | 10 | 15.2769 | 16.2520 | 17.2894 | 18.3930 | 19.5670 | 20.8160 | 22.1446 | 1.8566 |
| 12 | 11 | 17.2520 | 18.3532 | 19.5247 | 20.7710 | 22.0968 | 23.5072 | 25.0076 | 1.9751 |
| 13 | 12 | 19.3532 | 20.5885 | 21.9027 | 23.3008 | 24.7880 | 26.3702 | 28.0534 | 2.1012 |
| 14 | 13 | 21.5885 | 22.9665 | 24.4325 | 25.9920 | 27.6510 | 29.4160 | 31.2936 | 2.2353 |
| 15 | 14 | 23.9665 | 25.4963 | 27.1237 | 28.8550 | 30.6968 | 32.6562 | 34.7406 | 2.3780 |
| 16 | 15 | 26.4963 | 28.1875 | 29.9867 | 31.9008 | 33.9370 | 36.1032 | 38.4076 | 2.5298 |
| 17 | 16 | 29.1875 | 31.0505 | 33.0325 | 35.1410 | 37.3840 | 39.7702 | 42.3087 | 2.6912 |
| 18 | 17 | 32.0505 | 34.0963 | 36.2727 | 38.5880 | 41.0510 | 43.6713 | 46.4588 | 2.8630 |
| 19 | 18 | 35.0963 | 37.3365 | 39.7197 | 42.2550 | 44.9521 | 47.8214 | 50.8738 | 3.0458 |
| 20 | 19 | 38.3365 | 40.7835 | 43.3867 | 46.1561 | 49.1022 | 52.2364 | 55.5706 | 3.2402 |
| 21 | 20 | 41.7835 | 44.4505 | 47.2878 | 50.3062 | 53.5172 | 56.9332 | 60.5672 | 3.4470 |
| 22 | 21 | 45.4505 | 48.3516 | 51.4379 | 54.7212 | 58.2140 | 61.9298 | 65.8827 | 3.6670 |
| 23 | 22 | 49.3516 | 52.5017 | 55.8529 | 59.4180 | 63.2106 | 67.2453 | 71.5375 | 3.9011 |
| 24 | 23 | 53.5017 | 56.9167 | 60.5497 | 64.4146 | 68.5261 | 72.9001 | 77.5533 | 4.1501 |
| 25 | 24 | 57.9167 | 61.6135 | 65.5463 | 69.7301 | 74.1809 | 78.9159 | 83.9531 | 4.4150 |
| 26 | 25 | 62.6135 | 66.6101 | 70.8618 | 75.3849 | 80.1967 | 85.3157 | ..... | 4.6968 |
| 27 | 26 | 67.6101 | 71.9256 | 76.5166 | 81.4007 | 86.5965 | ..... | ..... | 4.9966 |
| 28 | 27 | 72.9256 | 77.5804 | 82.5324 | 87.8005 | ..... | ..... | ..... | 5.3155 |
| 29 | 28 | 78.5804 | 83.5962 | 88.9322 | ..... | ..... | ..... | ..... | 5.6548 |
| 30 | 29 | 84.5962 | 89.9960 | ..... | ..... | ..... | ..... | ..... | 6.0158 |